Hobby Electronics

December 78
40p

LIGHT BEAM TELEPHONE PROJECT

Audio Mixer Project
Choose your own arrangement

Electronic Metronome
Beat out the time

Dice Project
Roll your own

Calculator Specs
What they mean

DIY Printed Circuits
Simple — using Hobbyprints

Radio Servicing
Ten quick tips

TV Programagame Reviewed
10 games in one kit

Soldering Iron Offer
£2.35 all inclusive

OSTS "One Stop Technology Shopping" now from ambit international ®

Ambit stoppress....news on items available.....KV1210: triple AM tuning diode with 2·9v bias only £2.75.....DT1200 Digital frequency readout module ...... 911223 ultra low THD/IMD mpx decoder module £9.95.......944378 'Hyperfi' mpx decoder with post decoder muting and pilot cancel £19.95...... VMOS

COUNTER ATTRACTIONS:

New this month from Intersil, the ICM 7216. This is probably the most significant new IC for frequency counter/timer applications ever devised, It drives a full 8 digit display (LED) and operates on inputs of up to 10MHz minimum. The single 28 pin DIL also has:- •Leading zero blanking •Frequency ratio •Period •Unit counter •Time Interval •overrange The IC cost is £19.82, and the 10MHz HC18U Xtal £2.50 (for timebase functions). The circuit data is free with the IC, or £1 purchased separately. Input preamp board £7.00.

New from Ambit is the MC3357. 6v, 2mA standby NBFM IF, detector and squelch with 10.7 - 455 kHz balanced mixer, onboard oscillator device, and 5uV sensitivity, It is ideally suited to our CFM and LFY filter series, and costs £3.12 with full data. Xtal £2.50.

*Please note that OSTS prices exclude VAT at 8% throughout this side of the page. Most **ambit** items are at 12½% except those marked •. Please keep orders separately totalled, although a single combined payment, and 25p postage charge, will be sufficient.*

CD4000 CMOS

4000	17p	4059	563p	4522	149p
4001	17p	4060	115p	4527	157p
4002	17p	4063	109p	4528	102p
4006	109p	4066	53p	4529	141p
4007	18p	4067	400p	4530	90p
4008	80p	4068	25p	4531	141p
4009	58p	4069	20p	4532	125p
4010	58p	4070	20p	4534	614p
4011	17p	4071	20p	4536	380p
4012	17p	4072	20p	4538	150p
4013	55p	4073	20p	4539	110p
4016	52p	4075	20p	4541	141p
4017	80p	4076	90p	4543	174p
4018	80p	4077	20p	4549	399p
4019	60p	4078	20p	4553	440p
4020	93p	4081	20p	4554	153p
4021	82p	4082	20p	4556	77p
4022	90p	4085	82p	4557	386p
4023	17p	4086	82p	4558	117p
4024	76p	4089	150p	4559	388p
4025	17p	4093	50p	4560	218p
4026	180p	4094	190p	4561	65p
4027	55p	4096	105p	4562	530p
4028	72p	4097	372p	4566	159p
4029	100p	4098	110p	4568	281p
4030	58p	4099	122p	4569	303p
4031	250p	4160	90p	4572	25p
4032	100p	4161	90p	4580	600p
4033	145p	4162	90p	4581	319p
4034	200p	4163	90p	4582	164p
4035	120p	4174	104p	4583	84p
4036	250p	4175	95p	4584	63p
4037	100p	4194	95p	4585	100p
4038	105p	4501	23p		
4039	250p	4502	91p		
4040	83p	4503	69p		
4041	90p	4506	51p		
4042	85p	4507	55p		
4043	85p	4508	248p		
4044	80p	4510	99p		
4045	150p	4511	149p		
4046	130p	4512	98p		
4047	99p	4513	206p		
4048	60p	4514	260p		
4049	55p	4515	300p		
4050	55p	4516	125p		
4051	65p	4517	382p		
4052	65p	4518	103p		
4053	65p	4519	57p		
4054	120p	4520	109p		
4055	135p	4521	236p		

Micromarket — PRICES SLASHED

6800 series

6800P	6.50
6820P	£6
6850P	2.75
6810P	£4
6852	3.65

8080 series

8080	6.30
8212	2.30
8216	1.95
8224	3.50
8228	4.78
8251	6.25
8255	5.40

MEMORIES

2102	£1.70
2112	£3.40
2513	£7.54
4027	£5.78
2114	£10
2708	£10.55

Development

MEK6800	£220
TK80	£306

AMI, Signetics TI, Intersil, Harris etc. OA

Voltage Regs

NEW LOW PRICES

7800 series UC TO220 package 1A	all 95p
7900 series UC TO220 package 1A	all £1
78MUC series TO220 package ½A	all 90p
78LCP series TO92 100mA	all 35p
L200 up to 3A/adjustable V&A	195p
78MGT2C ½amp adjustable volts	175p
79MGT2C ½amp adjustable volts	175p
723C precision controller	65p

MAINS FILTERS FOR NOISE/RFI etc

1 amp in IEC connector	£4.83
5 amp in 'wire in' case	£3.87
NE550A	73p

LINEARS non-consumer

BIMOS		LM324N	71p
CA3130E	84p	LM339N	66p
CA3130T	90p	LM348N	186p
CA3140E	35p	LM3900N	60p
CA3140T	72p	709HC to5	64p
CA3160E	90p	709PC dil	36p
CA3160T	99p	710HC to5	65p
Op amps		710PC dil	59p
LM301AH	67p	723CN	65p
LM301AN	30p	741CH to5	66p
LM308H	121p	741CN 8dil	27p
LM308N	97p	747CN	70p
LM318H	279p	748CN	36p
LM318N	224p	NE531T	120p
		NE531N	105p

OPTO 7 seg displays

0.43" High Efficiency HP:

5082-7650	red CA	233p
5082-7653	red CC	
5082-7660	yellow CA	
5082-7663	yellow CC	
5082-7670	green CA	
5082-7673	green CC	

0.3" Standard HP

5082-7730	red CA	147p
5082-7740	red CC	

0.5" Fairchild

FND500	red CC	150p
FND507	red CA	150p

TLL:Standard AND LP Schottky

All prices listed in pence •

	'N'	'LSN'		'N'	'LSN'		'N'	'LSN'		'N'	'LSN'
7400	13	20	7455	35	24	74126	57	44	74185	134	
7401	13	20	7460	17		74128	74		74188	275	
7402	14	20	7463			74132	73	78	74190	115	92
7403	14	20	7470	28		74133		29	74191		
7404	14	24	7472	28		74136		40	74192	105	180
7405	18	26	7473	32		74138		60	74193	105	180
7406	38		7474	27	38	74139		60	74194	105	187
7407	38		7475	38	40	74141	56		74195	95	137
7408	17	24	7476	37		74142	265		74196	99	110
7409	17	24	7478			74143	312		74197	85	110
7410	15	24	7480	48		74144	312		74198	150	
7411	20	24	7481	86		74145	65		74199	160	
7412	17	24	7482	69		74147	175		74248		90
7413	30	52	7483A			74148	109		74251		90
7414	51	130	7484	97		74150	99		74253		105
7415		24	7485	104	99	74151	64	84	74257		108
7416	30		7486		40	74153	64	54	74279		72
7417	30		7489	205		74154	96		74283		120
7420	16	24	7490	33	90	74155	54	110	74290		120
7421	29	24	7491	76	110	74156	80	110	74295		120
7422	24	24	7492	38	78	74157	67	55	74298		100
7423	27		7493	32	99	74158		60	74258		110
7425	27		7494	78		74159	210		74260		26
7426	36	27	7495A	65	99	74160	82	130	74365		49
7427	27	29	7496	58	120	74161	92	78	74366		49
7428	35	32	7497	185		74162	92	130	74367		43
7430	17	24	74100	119		74163	92	78	74368		49
7432	25	24	74104	63		74164	104		74375		60
7433	40	32	74105	62		74165	105		74379		130
7437	40	24	74107	32	38	74166			74399		150
7438	33	24	74109	63	38	74167	20		74445		92
7440	17	24	74110	54		74168			74447		90
7441	74		74111	68		74169		200	74490		140
7442	70	99	74112	88		74170	230	200	74668		110
7443	115		74113		38	74172	625				
7444	112		74114		38	74173	170				
7445	94		74116	198		74174	87	120			
7446	94		74118	83		74175	87	110			
7447	82		74119	119		74176	75				
7448	56	99	74120	115		74177	78				
7449		99	74121	25		74180	85				
7450	17		74122	46		74181	165	350			
7451	17	24	74123	48		74182	160				
7453	17		74124			74183		210			
7454	17	24	74126	38	44	74184	135				

ICM7217 - count & display £9.50
ICM7207 - clock pulse IC £4.95
ICM7208 - count & display £14.95
ICL7106CP - LCD DVM IC £9.55
KIT £24.80
LED DVM with ICL7107 £20.65

Ambit overspill

the remainder of the column is not OSTS

Varicap diodes VAT 12.5%

BA102	30p
BA121	32p
ITT210	30p
BB105B	40p
BB104B	45p
5xBB104B	200p
MVAM2	148p
MVAM115	105p
MVAM125	105p
matching to a max of 6 diodes	25p per diode (1%)
KV1210	275p

PIN & switching VAT 12.5%

BA479 pin	35p
tda1061 pi-network attenuator	95p
BA182 bandswitch diode	21p
10 for	150p

Requests for the next issue of the catalogue now being "booked" for despatch immediately it is ready (about November). Please send 45p to reserve a copy.

MISCELLENY

NE555	30p
NE556	78p
NE558	180p
LM3909	72p
11C90DC	1400p
8629 divide by 100 to 150MHz	4.20p
95H90DC 320MHz divide by ten	7.80p

From the World's leading radio innovation source:

Apart from the MC3357, mentioned alongside, Ambit has the first easy-to-use low noise, low cost UHF dual gate MOSFET - the BF960 from Siemens. With a gain of 18dB, and a noise figure of only 2,8dB at 800MHz, you will see what we mean. At 200 MHz, the gain is 23dB, and NF only 1.6dB. Combine these figures with the famous ease of use of a dual gate MOSFET, and you have the easiest and most effective front end device yet. £1.60 each

Moving Coil Meters

Ambit offers a very wide range of low cost meters, together with the unique 'Meter Made' scale system for professional grade scale customizing:

Series	Scale Area	illumination	cost•
900	14x31mm	internal 12v	250p
920	30x50mm	from behind	275p
930	36x63mm	internal 12v	375p
940 twin	35x45mm	from behind	350p
950	55x45mm	from behind	300p

Stock movement 200uA/750Ω. The 930 series is 5% linear, others are 77uA at 50% FSD. These and many others available in quantity for OEMs *SAE for full scale details please. (Not in cat.)*

Radio;Audio;Comms ICs:

Only the very best quality - and only types we have used in our own laboratory tests

Radio frequency + mixers + oscillator(s)		
TDA1062	DC to VHF front end system	1.95
TDA1083/ULN2204	am/fm/audio in one IC	1.95
TDA1090/ULN2242	am/fm hifi tuner system	3.35
HA1197	LF/30MHz am receiver system	1.40
CA3123E/uA720	LF/30MHz linear system	1.40
TBA651	LF/30MHz linear system	1.81
SD6000	DMOS RF/Mixer pair	3.75
IF amplifiers		
CA3089E/KB4402	famous FM IF system	1.94
HA1137W/K	4420 as 3089 + deviation mute	2.20
CA3189E	update with deviation mute	2.75
TBA120a/SN76660N	FM if and detector	0.75
TBA120S	hi gain version TBA120	1.00
MC1350P	agc IF amp	1.20
MC1330P	synch AM demodulator	1.35
MC1495L	precision 4 quad multiplier	6.86•
MC1496P	popular double balanced mixer	1.25
Communications circuits		
KB4406	differential amplifier	0.50
KB4412	2 bal.mixers/agc/gain/doub. conv	2.55
KB4413	am/fm/ssb det. AGC, ANL, mute	2.75
KB4417	3mV mic processor preamp	2.55
KB4423	FM noise blanker system	2.55
Audio preamps		
LM381	stereo high gain/low THD	1.81
LM1303	stereo audio optimized OA	0.99
TDA1054	high quality with alc option	1.95
KB4417	see above	
Audio Power amps		
TBA810AS	7W RMS overload protected	1.09
TDA2002	8W/2Ω in pentawatt package	1.95
TDA2020	15W RMS hifi power dc coupled	2.99
TCA940	10W higher voltage 810	1.80
ULN2283	1W 2.5 to 12 v supply capability	1.00
LM380N8	1W power	1.00
LM380N14	2.5W power	1.00
HA1370	HiFi 15w in easy heatsink pack	2.99
Stereo Decoder Devices		
MC1310/KB4400	original pll decoder	2.20
CA3090AQ	RCA's pll decoder	3.25
uA758	Buffered version of 1310	2.20
LM1307/uA707	non pll type	1.55
HA1196	advanced adj.sep pll low thd	3.95
HA11223	newpilot cancel low thd/imd	4.35

All ambit decoders are supplied with the LED beacon of your choice. Please state colour.

Discrete semiconductors

Some of the biggest stocks of specialist MOS and FET transistors for radio in the UK.

BF900	80p•	40673	55p•	40822	43p•
40823	51p•	MEM680	75p•	BF256S	34p•

Most types for most RF circuitry, inc. new UHF T package types etc. See price list.....

Hitachi VMOS 100W power devices:

Hitachi 2SK134 /2SJ48 100W comp. VMOS. Data and circuit info £1, and the devices themselves for £14.00 a pair •

DISCRETE LEDs from Telefunken, square sided and round, AMBIT has the best value......

LED size (mm)	2.5x5	5 dia	2.5dia
RED	17p	14p	14p
Yellow	20p	15p	15p
Green	20p	16p	16p
Orange	24p /he	29p/heL	17p

he= high efficiency L= lens end

10% disc for 10 25% per 100 mix

Switch Systems: Check our combinations !

A very wide selection of BOTH Alps SUB series units, (Schadow/AB/Oreor compatible) & the miniature Dialistat units. Available in DIY systems for maximum flexibility and low cost.

And Finally

Further details of these, and many more of the wonders of the world of wireless in the new Ambit catalogue - with magazine supplement. 45p inc pp etc.

Phone (0277) 216029/227050 9am-7pm callers welcome anytime

Coils & Filters by TOKO

After a period of relative price stability, please note that some prices are increased as a direct result of the failure of £ versus stronger trading currencies. (Mainly Yen)

7 & 10mm IFTs for AM/FM - 1000s es		
455/470kHz	most types of appcns	30p
10.7MHz		33p
Short Wave Coils sets		
Now two ranges of impedance/coupling ea		33p
TV video and sound IFs/detectors		
Another new range in 10mm		33p
6MHz ceramic IF sound filter		80p
Molded VHF coils full catalogue 15p		
Ultra stable coils for 30 - 200MHz from		20p
Chokes - biggest range/biggest stocks		
Most E12 values ex stock, any to order		
78A series	1uH to 1mH	16p
8R8 series	100uH to 33mH	19p
10RB series	33mH to 120mH	33p
FM IF FILTERS ceramic and linear phase		
CFSE/SFE10.7	stereo ceramic IF 10.7MHz filters in 5 groups	50p
CFS810.7	mono/roofing IF filter	50p
BBR3125N	4pole linear pahe 10.7MHz	150p
BBR3132A	6pole linear phase 10.7MHz	250p
MPX pilot tone filters for 19 & 38kHz		
BLR3107N	Stereo 4k7 impedance	215p
BLR2007	Stereo 3k3 impedance	220p
BLR3152	Mono 4k7 impedance	100p
BLR3157	Mono 4k7/3k0 imp	100p
AM/FM/SSB IF FILTERS		
MFL series	2.4kHz ssb /455kHz carrier	1195p
MFH series	4/5/7kHz BW on 455kHz	195p
MFK series	7/9kHz BW on 455kHz	165p
LFY455D	12kHz 4 ele ladder on 455kHz	125p
CFM2455	6kHz micro mechanical ..	65p
SFD455/470kHz	murata IF filter	85p
CFT455B/C	6/8kHz min + 2IFTs	60p
CFU470C	6kHz on 470kHz	65p
Ratio Detectors for FM/NBFM		
1A651/7	455kHz ratio det	135p
KAN1508/9	10.7MHz ratio detector	66p
94ACS15106/7	10.7MHz ratio detector	66p
Quadrature detectors for CA3089E etc		
KACSK586HM	single	33p
KACS34342/3	double	66p
Polyvaricon tuning capacitors + trimmers		
2A20ST7	2x266pF AM	95p
CY22217Z	2x335p AM 2x20pF FM	175p
CY23217PX	2x335pF AM 3x20pF FM (2 trimmers)	245p

Tuner Modules

From the biggest and best range...............

TUNERHEADS for 88-108MHz band 2 'varicap)		
EF5803	6 cct, 3 MOSFETs, amp. osc.	19.75
EF5801	6 cct, 2 MOSFETs, osc op	17.45
EF5600	5cct, MOSFET RF, by TOKO	14.95
EF5400	4cct balanced mixer/pin agc	9.75
EC3302	3cct FET input miniature	8.25
TUNERSETS by LARSHOLT (head+IF)		
7252	Dual MOS head/low dist IF	26.50
7253	FET head, mpx decoder inc	26.50
IF AMPLIFIERS all with deviation mute, agc, afc, meter drives etc		
7020	HiGain dual ceramic filter	6.95
7030	Mos preamp, linear phase filter	10.95
7 130	2 mos preamps, 3 lpfilters	16.25
NBFM1	455/470kHz NBFM module	9.95
MPX decoders, all with pilot tone filters and buffer amplifiers for min 300mV RMS		
92310	1310 based system	6.95
93090	3090AQ based system	8.85
91196	HA1196 based + birdy filter	1299
91196B	HA1196 based + birdy filter + 2 x LM380 audio monitor amps	16.45
911223	HA11223 based system	12.50
AM RADIO		
91197	The original MW/LW varicap tuner with electronic switch	11.85
9122	The uniband tuner module	13.22
AM FM RADIO UNITS		
71083	Using TDA1083, provides a complete MW/LW/FM portable radio chassis for clock radio etc	12.95
71083D	Drive/dial system for 71083	1.75

SPECIALS: TUNERHEADs in the range 40-200MHz to special order

The EF5803 and EF5400 are available to cover bands in the region described. The costs depend on quantity and actual mods required to cover the desired band. Max coverage approx. 20% of centre frequency selected. Also, please allow 3-5 weeks delivery for these items.

2 Gresham Road, Brentwood, Essex.

Hobby Electronics

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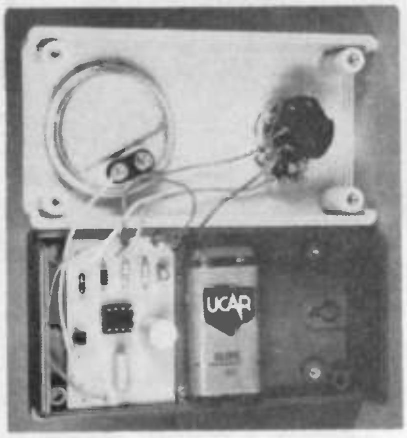

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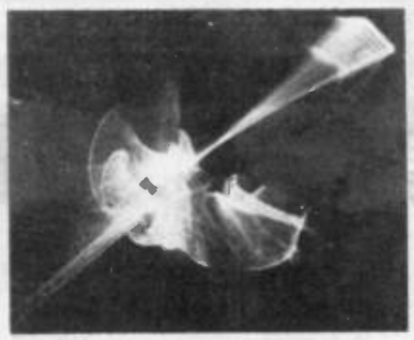

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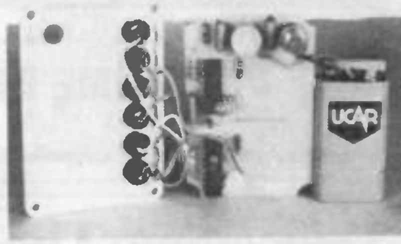

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UNBELIEVABLE WATCH BARGAINS

VT01
5 FUNCTION
LCD. Hour. Min. Sec. Month. Date. S/S strap. Backlight.
ONLY £8.95

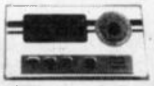
VT07
12 FUNCTION CHRONOGRAPH
Hour. Min., Sec., DATE. Month. 1/100th Sec. Time. 1 or 2 Event.
ONLY £13.95

VT03
SOLAR ALARM
Hour. Min. Sec. Month. Date. Day. alarm any time in 24 hour day.
ONLY £24.95

VT04
SOLAR CHRONOGRAPH
As VT07 but with solar panel
ONLY £23.95

VT05
CHRONOGRAPHY/ ALARM
Dual Time Zone Chrono lap time alarm
ONLY £37.95★

VT08 ALARM
Alarm only version of VT05
ONLY £24.95



VT06
ALARM/STOP WATCH CLOCK
& Snooze Alarm. Stop watch.
ONLY £15.95

Presentation boxes not included. Please add 65p

FREE FITTED SOUND MODULATOR

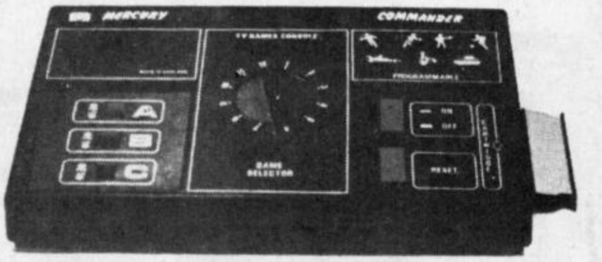
'MERCURY COMMANDER'

READY BUILT

ECONOMY CARTRIDGE SYSTEM (G.I. DEDICATED CHIPS)

Designed and built in Britain by Teleng, one of Europe's largest TV Games manufacturers.

Mercury Commander — Complete with 10 Game Cartridge, 2 joysticks. Mains adaptor — in colour with Videotime TV Sound — No Additional Costs .... **£39.95★**



Plus additional cartridges

Stunt Rider with hand control, 4 games .... **£16.90★**

Road Race 2 games ...... **£10.90★**

Tank Battles with 2 joystick controls .... **£21.90★**

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(Trade & Export Enquiries welcome)

Dorachime. The 8-Tune Door Chime Kit at £12·50 + P&P

Sounds Simply Wonderful

(Offer closes 31st January 1979)

If you are the sort of person who delights in novel possessions, this will appeal to you.

Ready to surprise your visitors as their fingers press the bell-push are 8 tunes, stored in Dorachime's micro-circuitry. You can switch between them as you like, merely with a movement to the 'Tune Select' control. Tempo control speeds or slows the music to suit your mood. Ranging from 'Greensleeves' to 'Sailors Hornpipe', the selection has been carefully made to ensure you have something appropriate for every visitor.

The effect on your guests is both stunning and amusing. It is worth the price of the Dorachime, for instance, if just once your bell can play 'O Come all Ye Faithful' to surprise your friends at Christmas. You can see the possibilities.

Technologically advanced

You may have read in the prestige national press of the research effort currently devoted to micro computer chips. The Dorachime is a musical revelation of its progress.

It produces, from its powerful little loudspeaker, notes similar in value to a miniature electric organ.

NOW AVAILABLE
8 Chime ready-built at £15.50 + p&p
ALSO 24 Chime version
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*C1 Rule Britannia
D1 Land of Hope and Glory
E1 Oh Come All Ye Faithful
F1 Oranges and Lemons
*G1 Westminster Chimes
H1 Sailor's Hornpipe

* These tunes play longer if the push button is kept pressed.

MADE IN ENGLAND

You can connect the Chime in seconds to your existing bell circuitry, the only things needed to complete are two standard PP3 (P) batteries, wiring and bell push.

REMINDER
The DORAM Electronic Hobbies Catalogue is now available. To obtain your FREE copy send 25p contribution to postage and packing.

Blends with any decor

Many ordinary door chimes are bulky, even unsightly. The Dorachime measures a trim 5¼" × 3½" × 1½" and its smart white lines will blend sweetly with any colour scheme. Easily assembled in a couple of hours using a soldering iron, small screwdriver, pliers and wire cutters.

Order now. Guarantee of Satisfaction.

Send the coupon immediately. Your Dorachime will be delivered within 21-28 days. If you are not completely satisfied you may return your purchase within 30 days for a full refund.

Doram Electronics Ltd. PO Box TR8. Leeds LS12 2UF.

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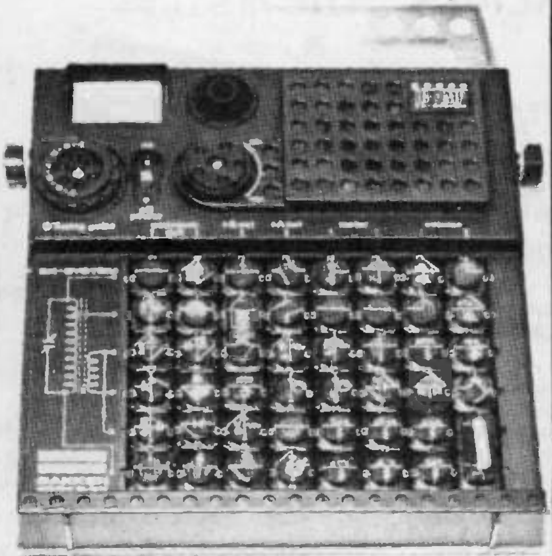
Doram Electronics Ltd Reg 1155856 HE 12

ELECTRONI-KIT

"EDUCATIONAL KITS OF EXCEPTIONAL QUALITY"

(AUDIO magazine)



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The above is just a *selection* of the circuits available — you can also design your own circuits with these superb new Denshi-Gakken **"EX"** construction kits.

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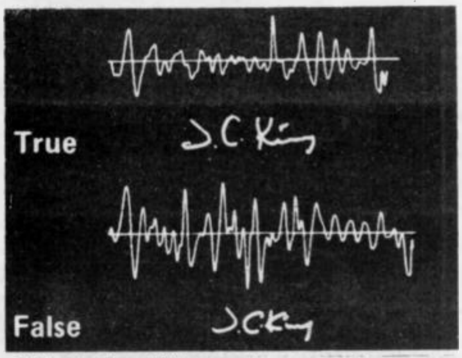
Monitor

ELECTRONIC DOTTED LINE



What's the difference between these two signatures? Very little, you may well reply. The computer-produced traces tell a different story, however. They're not based on the signatures as such but on the acceleration of the pen tip and the pressure used while writing.

By using a pen which is wired up to a computer, IBM claim to be able to accept a valid signature of a possible 3,000 with a success rate of 98.3%

Obvious applications are in banks and other places where identification is important.

GUINNESS GRACIOUS ME

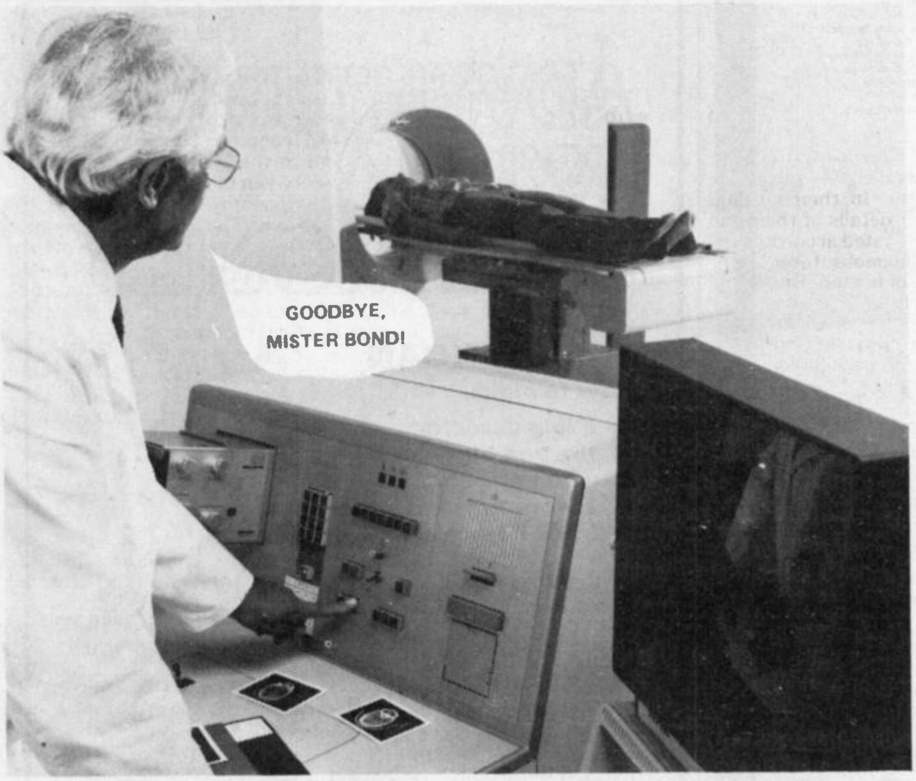
Guinness have installed an automatic weighing system at their St. James' Gate brewery in Dublin. The system, by Avery, uses punched (drunk?) cards to tell it exactly how much barley flake, roast malt or whatever to put in each batch of the brew.

What, we ask ourselves, is the world coming to? Automated Guinness!

The system includes digitising instrumentation, sequencing equipment and a printer.

Lord help Messrs G if the real Guinness affectionados got wind of this. Most people think of the hallowed Guinness brewery as a place where little folk in green linen trip happily around carrying pots of various smelly ferments which they tip into giant wooden vats according to an ancient and mystical procedure. The result of this happy endeavour is the marvellous black stout — and an occasional pea-green river Liffey (which the Dubliners are sometimes heard to refer to as the Whiffey).

Why, if this sort of thing is allowed to go on unchecked, it may enter such hallowed ground as winemaking or even (perish the thought) drinking!



Goldfinger is alive and well and working for Siemens! This gem (minus the baloon) was sent in to publicise the new 'Somaton' head to foot computer tomograph from Siemens and we thought it too good to miss.

THE 79 STEPS

Sinclair Radionics have again "broken the cost barrier" with a 79-step programmable calculator for under £25. The 'Enterprise', as well as the normal functions expected of a scientific calculator (trigonometric functions, logs, etc.) has seven independent memories which can be used under program control or manually. Other features include a forward or backward stepping facility for examining the stored program and conditional branching under program control.

Not content with selling just the calculator for under £25, Sinclair have thrown in a case, mains adaptor, alkaline battery and a three volume software library containing, in all, 316 programs as well as an instruction manual.

Sinclair Radionics, London Road, St. Ives, Huntingdon, Cambs. PE17 4HJ.

OBSOLETE DATA

We have just received a copy of the D.A.T.A. Book of Obsolete Integrated Circuits (8th edition, from London information at £21.25). This invaluable publication lists the electrical and physical characteristics of "every device which has become obsolete since 1965".

The total is nearly 24 000 digital, linear, memory and interface ICs.

It even gives the addresses of the 187 different firms who used to make them!

London Information (Rowse Muir) Ltd, Index House, Ascot, Berks.

News from the Electronics World

DIGEST

Pacific Airlines in California are taking delivery of 30 computerised ticket machines. Passengers will be able to insert any one of six credit cards.

The US airforce has placed a contract with a UK company to develop a microprocessor based fire detection system. Hopefully, the system will be able to give a lower rate of false alarms than previous systems. It seems that pilots tend to eject, leaving their sometimes uncombusted F111s to find their own way down!

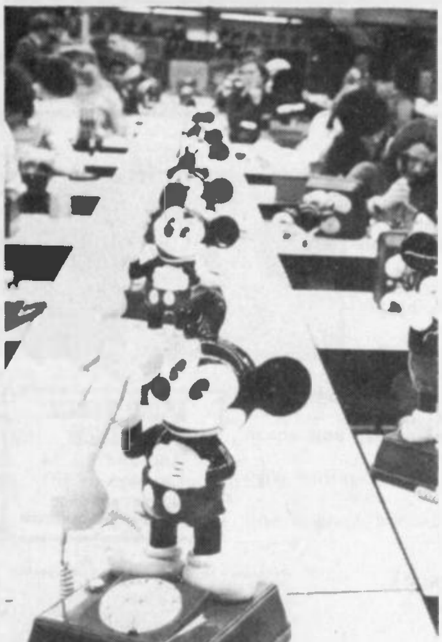
Researchers at Chelsea College have developed a system which "sucks up" sound. By using two loudspeakers and a microphone as well as some sophisticated electronics, they have succeeded in nullifying the noise from a ventilator.

Racal-Datacom have developed a microprocessor controlled, battery powered teleprinter that fits into a briefcase.

New in the land of the rising Sun, a laser-based video disc system from Matsushita. It can store up to 20 000 still pictures on one 20 cm disc — and you can even record them yourself.

The first chance for the general public to use Prestel, the Post Office's Viewdata service, was at the Motor Show.

SQUEAK, SQUEAK



Not content with Buzby, the Post Office has gone and introduced a new telephone that looks very Mickey Mouse indeed. Yes, folks, for a small extra charge (payable in cheese?) you could be the first kid on your block to be the proud (?) keeper of a brand new — latest technology — Mickey Mouse telephone! Available, for the time being, only in the London area (where, you may remember, rats started the great Plague), Mickey is the first of a whole new range of decorative phones that are due early next year.

FOUR OF A KIND

Probably the first thing any aspiring project builder needs (before even the infamous soldering iron) is a fistful of catalogues. The most useful being, in this respect, those from companies making and/or selling electronic components and the various tools, nuts, bolts, boxes, wires, solder etc. etc. etc. that put and hold the components together. Having acquired these, it becomes a great deal easier to make the usual compromise between prices and quality. As most firms publishing catalogues will operate a mail order service, it then becomes possible to gather all the bits for a project in the comfort of your own home (providing someone else is willing to nip round the corner to the post box for you). Four catalogues that we've been sent over the past month came from some quite different companies: Doram who specialise in DIY kits of various sorts; Home Radio and Stevenson who supply components and accessories; and Vero who make boards and boxes.

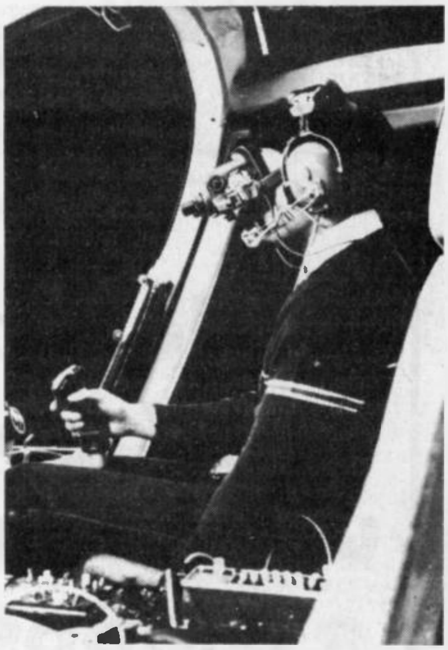
In their 40 page catalogue, Doram give details of their audio and test gear kits (star rated according to difficulty of construction), books, tools and various other items as well as their range of ready built test gear, available from Doram Electronics Ltd, P.O. Box TR8, Wellington Road Estate, Wellington Bridge, LEEDS LS12 2UF for 25p for P&P.

Home Radio's catalogue shows a large range of components, hardware, tools, test gear and books. Practically every item is clearly illustrated, down to the last nut, bolt or washer, and precisely described, 128 pages, available from Home Radio (Components) Ltd, 240, London Road, Mitcham, Surrey CR4 3HD for £1.25 including P&P.

Stevenson display a good range of components, as well as a stock of hardware bits which should cater for most project builders, 40 pages available from Stevenson, 236, High Street, BROMLEY, Kent, BR1 1PW, free of charge.

The Vero catalogue shows off their range of well known circuit boards and related accessories, as well as their equally well known range of boxes and cases. All the items are clearly illustrated and precisely dimensioned, with instructions for use being given in many instances. 36 pages available from Vero Electronics Ltd, Retail Dept, Industrial Estate, Chandlers Ford, Hampshire, SO5 3ZR, for 25p for P&P.

WHAT A SPECTACLE!



The man in the modern version of the iron mask is a pilot with the Swiss Helicopter Alpine Rescue Service (SHARS) and the contraption on his face is a modified set of ITT night vision glasses. Most of SHARS's work is in the worst of the weather (since that is when people most need rescuing). With the aid of the glasses the wearer can distinguish between fields, woods and hills — which would appear as complete blackness to the naked eye. Two pilots are essential when the glasses are used, as the wearer cannot see the instruments! Even so, SHARS teams have managed to land in total blackness, with one of the team flying and the other giving directions.

The glasses use electronic vision intensifiers to produce a simulated view, rather like a TV picture, and were originally developed for the military — nice to see them being put to a more humanitarian use.

ERRATA

Last month we gave the impression that components were available from RS components directly to the amateur. In fact, RS supply only to 'trade'. However, all RS components are available from most major retailers.

The parts list of the amplifier in last month's issue should have included: RV1 100k dual linear; RV2 100k dual linear; RV3 47k linear; RV4 47k dual logarithmic.

In the Waa-Waa circuit diagram, bottom of RV2 should also be connected IC1 pin 3. In the overlay, the input and output connections from C1 and C4 are via SW2.

SINCLAIR PRODUCTS. Microvision TV £172 PDM35 £27.25. Mains adaptor £3.24. Case £3.25. DM235 £48.30. Rechargeable battery units £8. Adaptor/charger £3.70. Case £8.50. Cambridge Prog. calculator £13.15. Prog. library £3.45. Mains adaptor £3.20. Enterprise calculator £20.95.

COMPONENTS. Send s.a.e. for full list. 1lb. FeCl £1.05. Dalo Pen 73p. 60 sq. ins. pcb 55p. Laminate cutter 75p. Small drill 20p. zn414 £1.05. pcb and extra parts for radio £3.85. Case £1. 1N4148 1.4p. AN4002 3.6p. 741 15p. NE555 23p. bc182b. bc183b. bc184b. bc212b. bc213b. bc214c 4.6p. Plastic equivs bc105. bc109. bcy71. bcy72 4.8p. ¼W 5% E12. Resistors 10R to 10M 1p. 0.8p for 50+ of one value. 16v electrolytics .5/1/2/5/10/22 mf 5p. 100mf 6p. 1000mf 10p. Polyesters 250v .015. .068. 1mf 1½p. Ceramics 50v E6 22pf to 47n 2p. Polystyrenes 63v E12 10pf to 10n 3p. Zeners 400mW E24 2v7 to 22v 7p.

TV GAMES. Send sae for data. AY-3-8500 + kit £8.95. AY-3-8600 + kit £12.50. Tank battles chip £6.90. Kit £7.05. Stunt cycle chip £6.90. Kit 5.60. Rifle kit 4.95.

TRANSFORMERS 6-0-6v 100ma 74p. 1½a £2.35. 6.3v £1.89. 9-0-9v 75ma 74p. 1a £2. 2a £2.60. 12-0-12v 100ma 90p. 1a £2.49.

IC AUDIO AMPS with pcb JC12 6w £1.60. JC20 10W £2.95. JC40 20W £3.95.

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T-DEC AND CSC BREADBOARDS s-dec £3.17. t/dec £4.02. u-deca £4.40. u-decb £7.05. 16 dil adaptor £2.14. Exp300 £6.21. exp350 £3.40. exp 650 £3.89. exp4b £2.48.

BI-PAK AUDIO MODULES. s450 £23.51. AL60 £4.86. pa100 £16.71. spm80 £4.47. bmt80 £5.95. Stereo 30 £20.12.

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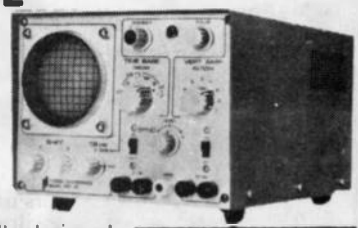
FEATURES



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Input Voltage-Max — 600V P-P

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AT BREADBOARD '78 Stand D3

Metronome

For those of you with musical aspirations, this project will help you to get into rhythm without beating about the bush.

TICK, TICK, TICK. Not marks of scholastic approval, but the sound made by our electronic metronome. The metronome is designed to help those learning to play a musical instrument who find that keeping time is one of the first hurdles to be encountered. A sense of natural rhythm is not present in most of us and the metronome, by producing a series of regular beats, is a considerable help in the early days of a potential Andre Previn or Brian May (according to taste).

We would claim that in this case the electronic version is an improvement over the clockwork mechanisms that many of you will have seen. Doing things the electronic way need not be the best method *all* the time but judge for yourselves if our self-contained little box of tricks is not a better proposition than the rather bulky, fragile and often expensive mechanical analogue.

TICK IN TIME

You can see that our metronome was built into a small plastic case with just one control on the front panel. This is the on/off and rate control. The beat can be varied between about 30 and 120 beats per minute, the beat being reproduced by the GPO 'insert' mounted behind the decorative holes on the panel.

CONSTRUCTION

This is largely a matter of choice. We show two alternative component layouts, one using printed circuit board (PCB) specially designed for this project, the other using a general purpose board. Whichever method you care to use, follow the overlay shown with care. It's important to get the IC, transistors, and electrolytic capacitors the right way round if you don't want a 'metronome mort' on your hands.

Parts List

RESISTORS

R1	2k2	
R2	47k	
R3	10k	

CAPACITORS

C2	10n	polyester
C1	1u0	35V tantalum
C3	10u	16V electrolytic

POTENTIOMETER

RV1	1M0 linear with switch

SEMICONDUCTORS

IC1	555 timer IC
Q1	BC184L
D1	1N914

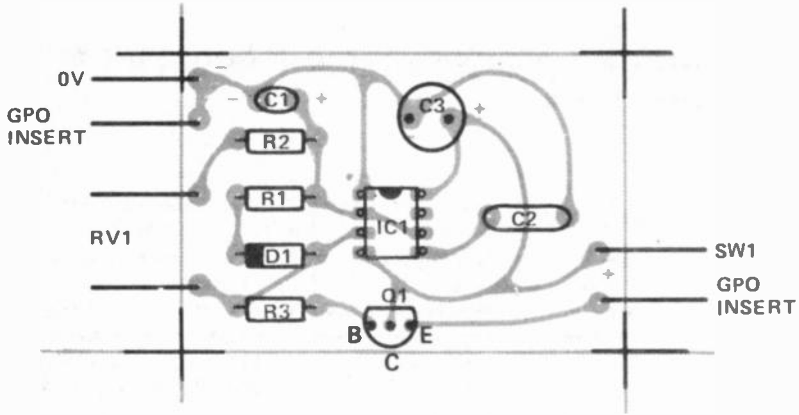
MISCELLANEOUS

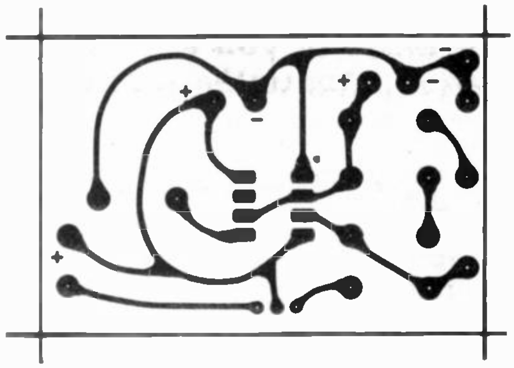
PCB as pattern, GPO insert, PP3 battery, Vero box, wire etc.

Looking through the adverts in this issue should locate most of the components used in the Metronome. If you decide to use the PCB it will be available from people like Ramar, Crofton, and Tamtronix. Vero board should be available from most general component suppliers, Vero also

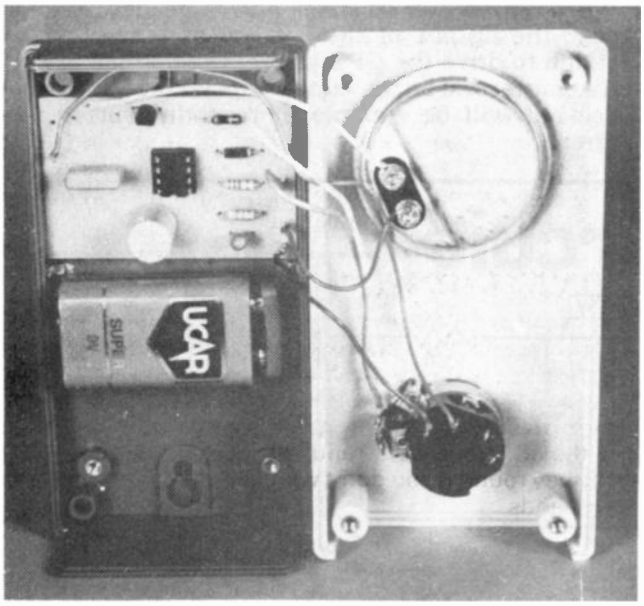
The GPO insert will be cheapest if bought from a shop dealing in surplus GPO goods but it is also possible to buy this device from the more usual component retailers.

Approximate cost £5.00.



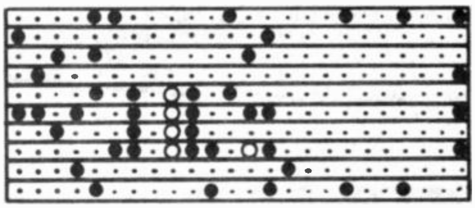


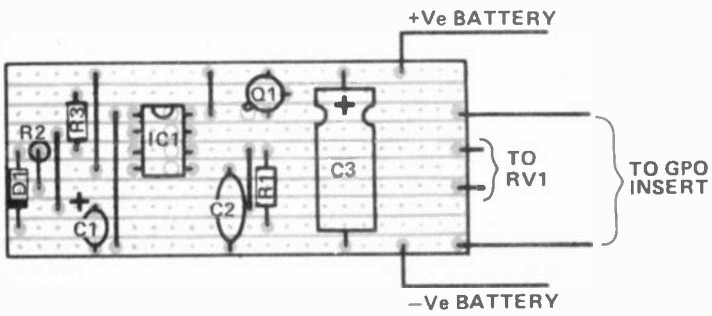
The 'component overlay' above relates the positions of the components on the printed circuit board to their places in the circuit diagram. The metronome is shown opened (below left) to indicate where the major components lie. The printed circuit foil pattern is given (above right).

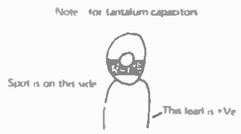


Drill the front panel with care as any sloppy work here will show up every time you demonstrate your new project. We used Letraset to produce the front panel markings.

When you've finished everything, it's best to put the project to one side for a few hours before carefully checking everything. When this is done, switch on and hopefully you will be rewarded by a series of rhythmic beats.

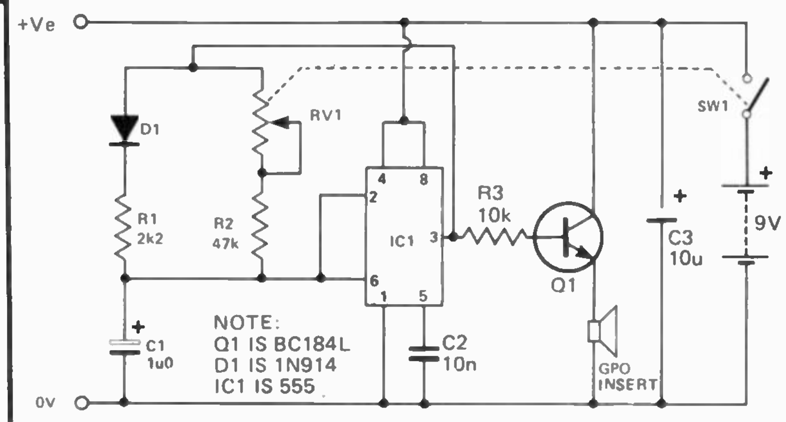






The Veroboard layout for the construction of the metronome is given here (above and left) as an alternative to the printed circuit board method. In the foil pattern (above), the large black dots represent solder joints while the circles represent breaks in the copper track.

How it Works



THE beat of the metrome is produced by applying a series of regular electrical pulses to the GPO insert which acts as a loudspeaker.

The pulses used to "drive" the GPO insert are produced by the integrated circuit IC1 called a '555'. This is a very versatile "timer" IC that can be used in a number of different circuit arrangements to produce single timing periods up to many minutes or, as in our case, a series of repetitive pulses.

The 555's internal circuitry consists, in the main, of two comparators and a switch. A comparator compares two voltages and produces an output that depends on the result of the comparison.

The two comparators are connected internally to two of the pins of the IC, one to pin two, the other to pin six. If the voltage on pin two is less than ⅓ of the supply voltage then the comparator connected to that pin will turn the output of the 555 on (the voltage at pin three will rise to the supply voltage). This happens when the circuit is first switched on as C1 is discharged. C1 is now charged via D1, R1 and RV1, R2. As the voltage on pin six reaches ⅔ of supply, however, the other comparator will turn the output of IC1 off (the voltage at pin three falls to zero). C1 will now discharge only via RV1, R2 as D1 does not allow current to flow now as it is reverse biased.

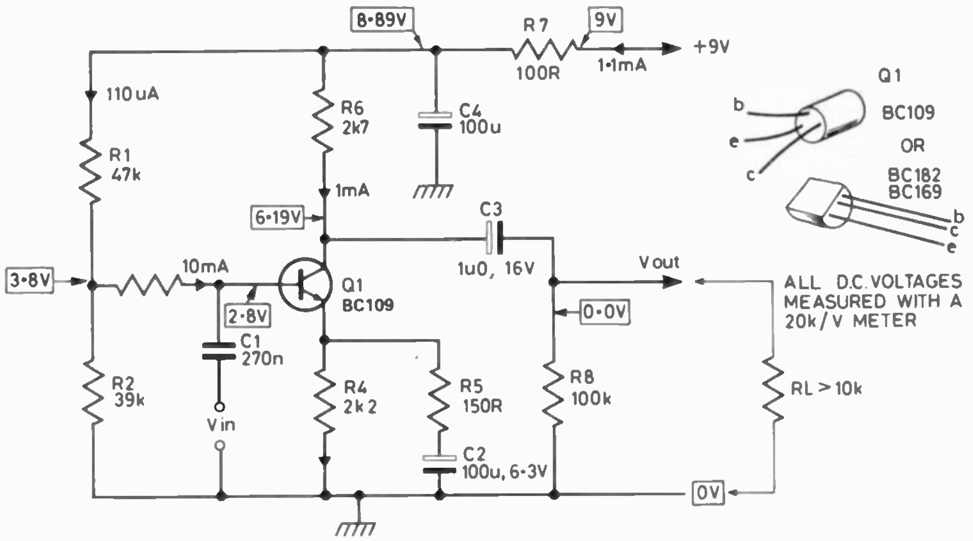
As R1 is of a far lower value than R2 plus RV1, the output of the 555 will be on for a far shorter time than it is off. Thus the timer produces a short, sharp pulse that is just what we want to produce a realistic metronome sound.

By altering the value of RV1 and thus the rate at which C1 is allowed to discharge, we can alter the rate at which the pulses are produced, and thus change the beat of the metronome.

Q1 is an emitter follower and is needed because the output of the 555 is not powerful enough to drive the GPO insert. The *voltage* at Q1's emitter will be the same as the voltage at its base but will be capable of providing more current.

Short Circuit

ONE TRANSISTOR AMPLIFIER



At first glance this may seem a rather complicated circuit — especially for a one transistor amplifier — one of the simplest active circuits in common use, but in fact it is simple enough in its operation. It's just a question of splitting it up into its constituent parts.

Starting with the power supply (from a 9V battery, typically), R7 and C4 provide circuit stability by smoothing the battery voltage. This means that sudden current drain will draw on the current stored in C4, rather than on the battery. Thus these sudden surges will have little effect on the voltage at the tops of R1 and R6 as C4 will be able to handle them.

Resistors R1 and R2 form what is called a divider. This provides a voltage of 3V8 at their junction and this is used to 'bias' the transistor. This means that it is added added to the input voltage to the circuit input voltage to the circuit in order to ensure that the average voltage between the base of the transistor and its emitter is about 0V6. This is essential for the correct operation of the transistor. If this voltage is too high, the transistor will overheat and if it is too low it will not pass enough current to operate.

The bias voltage is added to the alternating input voltage by means of C1. This is called a de-coupling capacitor. Any DC voltage which is present on the input will have no effect on the bias voltage but an alternating voltage will cause the base voltage of the transistor to vary about its bias voltage. This will cause the effective resistance of the transistor's emitter/collector junction to vary — the higher the base/emitter voltage, the lower the resistance. (This is true of NPN transistor — PNP ones operate in a different direction).

As the base voltage varies then, the current through R6 will vary also. As the top of R6 is fixed at 9V, the voltage on the bottom of it will follow the current variations. This voltage is then de-coupled by C3 (which removes the 6V19 DC and causes the output to vary about 0V).

The network formed by R4, R5 and C2 is necessary to provide stability in the face of two criteria keeping the base current at the right level and keeping the emitter at a constant voltage so that it doesn't move up and down and disturb the output voltage.

The voltage readings on the diagram are what you should expect to find during normal operation. They must be measured with a fairly good meter (about 20 000 ohms per volt) to gain an accurate estimate of their true value.

Deep Space Communication

Brian Dance examines the challenges of communications with interplanetary craft.

IT IS ONE of the triumphs of modern science that we can establish reliable communications with spacecraft at any point in the solar system provided they are not in the radio shadow of some large object as seen from the Earth.

Deep space communications are required for three main purposes

(i) To track spacecraft velocity and distance. This information is required to calculate trajectory and to compute velocity corrections so that the desired trajectory is obtained.

If a pulse is sent to the spacecraft and the on-board transponder immediately sends a pulse in response, the time delay before this pulse is received on earth is a measure of the distance of the craft. The Doppler frequency shift of this signal is a measure of its velocity towards or away from the earth.

(ii) To transmit command signals to the spacecraft. Such a command signal may, for example, switch on a small jet so as to alter the velocity of the craft or it may cause a television camera to point in a certain direction and transmit a picture, or it may switch on a piece of equipment. Many craft have a memory which will store command signals for use at a time when communications are not possible because the craft is behind a planet.

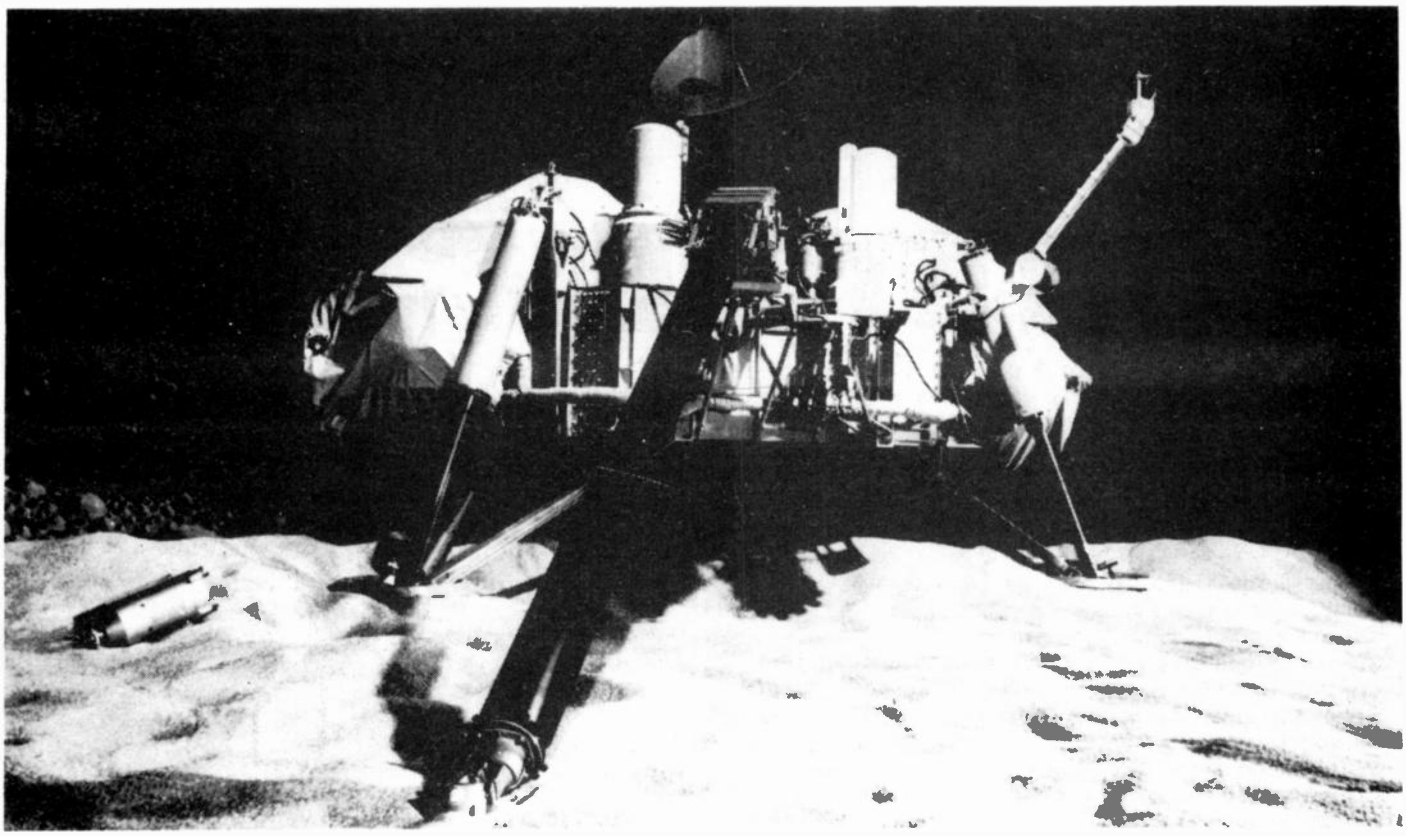
(iii) To send data and television pictures to the earth by telemetry.

During the past twenty years the USA has built up a world-wide network of Deep Space stations for interplanetary communication. This is in almost continuous use and is often receiving signals from quite a number of spacecraft simultaneously.

BRIEF HISTORY

The US Deep Space Communications Network is managed for NASA by the Jet Propulsion Laboratory of the California Institute of Technology (at Pasadena). Pioneering work on liquid and solid rocket propellants was carried out on the Pasadena site of the Guggenheim Aeronautical Laboratory as early as the mid-30's. However, it was the Jet Propulsion Laboratory's work on tracking and data recovery systems for the US army's guided missiles during the early 1950s which resulted in the development of the present Deep Space Network.

The US space programme commenced on 31st January 1958 with the launching of satellite "Explorer 1". This 14 kg spacecraft continued transmitting from Earth orbit until 23rd May 1958; it sent data to a three-station network established by the Jet Propulsion Laboratory incidentally confirming the existence of the Van Allen radiation belts around the Earth.



In September 1958, NASA was created by the US Congress for investigating problems for flight within and outside the earth's atmosphere 'for peaceful purposes to the benefit of mankind'. Two months later the control of the Laboratory was transferred from the US Army to the California Institute of Technology.

The Deep Space Network has provided tracking, command and data acquisition facilities for the Ranger, Surveyor and Lunar Orbiter projects for exploration of the moon, for the Mariner missions to Mars, Venus and Mercury and for the Viking missions for orbiting and landing on Mars. It also supported the Manned Space Flight Network and the Apollo lunar landing programme, apart from collecting data from Pioneers 10 and 11 and the Helios 1 and 2 craft which as the name implies were used to explore space close to the sun.

The Deep Space Network will be involved in even more work during the coming years. The current Pioneer mission to Venus involves receiving signals simultaneously from one large probe, three small probes, a 'bus' carrier vehicle and a Venus orbiting craft. The long duration Voyager 1 and 2 missions to the outer planets (Jupiter in 1979, Saturn in 1980/81 and possibly Uranus in January 1986 and Neptune in 1989) will be carried on simultaneously with work with the Viking craft on Mars and orbiting Mars. In addition, communications must be maintained with Pioneers 10 and 11 outside the orbit of Jupiter, support must be given to the West German space communications facilities working with the two Helios craft, and various other demands made by Deep Space Communications. A Jupiter Orbiter Probe is planned for launching by the Space Shuttle in January 1982 for arrival at Jupiter some two years and eight months later.

SEEKING LIFE OUT THERE

The Deep Space Network is used for many purposes besides deep space including pulsar and quasar studies. The aerials of this network are ideal for radar mapping the surfaces of the planets and the rings of Saturn. It is intended to use two of the aerials for Search for Extra-Terrestial Intelligence (SETI) — starting about 1979 over a five-year period and covering some 80% of the sky. A search will be made for evidence of radio signals from intelligent extra-terrestial life — advanced data processing being used to survey the sky over a million different frequency bands. A companion project to be undertaken by the Ames Research Centre will examine 500 selected stars to ascertain if any planets orbiting them are transmitting signals.

THE DSN

The American Deep Space Network employs huge high-gain parabolic dish aerials and very low noise receivers at widely separated places at various longitudes around the globe; this ensures that a spacecraft travelling beyond earth orbit is never out of view of all of the Deep Space Network stations unless it is behind a large object as seen from the Earth. Thus at least one of the stations can communicate with any craft at any time when it is not in radio shadow.

Deep space Network stations are located in groups at three places, Goldstone, California; at Madrid, Spain; and at Tidbinbilla, near Canberra, Australia. Each of these stations is equipped with a huge 64 m diameter dish aerial and two smaller 26 m aerials. Grouping the stations together saves money and avoids excessive duplication of equipment. All stations are linked by a special ground communications network which is part of the larger "NASCOM" (No relation! — Ed) network which provides communications between all of NASA's stations.

The ground communications facilities used by the Deep Space Network include INTELSAT communications satellite links and sub-oceanic cables as well as microwave links. Data received from spacecraft are transmitted over high-speed data circuits. Wide bandwidth circuits may carry television pictures of planets and their moons from a Deep Space Network station to the Control Centre at a rate of up to one picture in 48 seconds. In addition, range and velocity information about the spacecraft are transmitted from the receiving station to the Control Centre for navigational purposes. Command signals are sent to the Deep Space Network stations for transmission to the craft. Before transmission they are loaded into a command processing computer which automatically checks them.

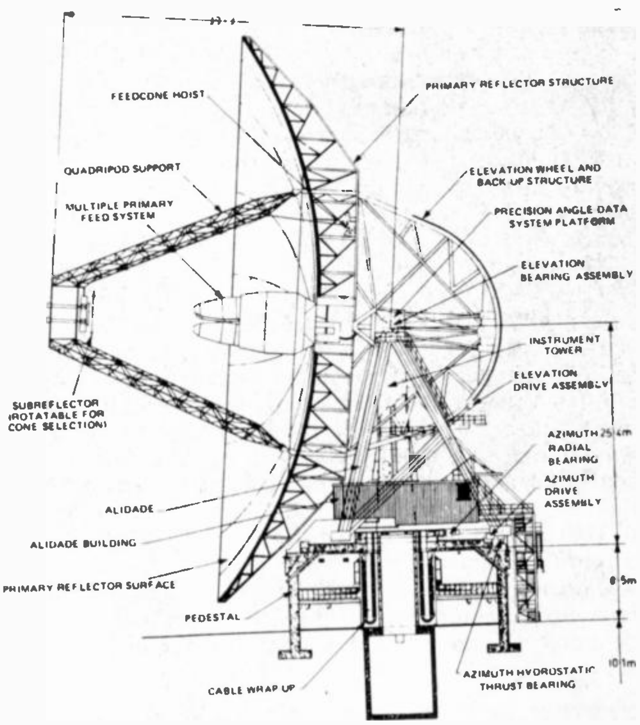
The Deep Space Network is not used during the launching phase of a mission. Launches take place from Cape Canaveral, Florida, and use the near-earth facilities of the US Air Force Eastern Test Range in the Atlantic together with the down-range elements of the NASA Spaceflight Tracking and Data Network (STDN) at Merritt Island, Florida. Communications ships and instrumented jet aircraft may also be employed during the launching stage. The STDN system is essentially concerned with manned space flights, earth satellites and lunar probes together with the launching phase of any spacecraft; it consists of 16 stations located throughout the world.

The Goddard Space Flight Centre located in Greenbelt, Maryland, operates the STDN network and the NASCOM network which links all STDN and DSN stations with control centres. The NASCOM network permits the transmission and reception of written messages, facsimile, voice, telemetry and commands by high-speed data lines.

The STDN system provides tracking and communications with the spacecraft during the launching phase, but about the time the launching vehicle is jettisoned and the spacecraft has been put onto its correct trajectory towards the desired planet, the Deep Space Network takes over all communications. It maintains a two-way radio link throughout the remainder of the deep space mission.

FREQUENCIES

The standard frequency band used for deep space communications is 2.1 GHz for the up-link from earth to spacecraft and 2.3 GHz for the down-link from spacecraft to earth, these frequencies being in the 'S' band. However, some spacecraft are also equipped with 8.4 GHz (X band) transmitters. Mariner 10 carried a low power X band transmitter not modulated with telemetry, but used with the S band signal for a dual signal for a dual frequency radio experiment. Voyagers 1 and 2 will have both S and X band high power transmitters. The X band down link will be able to send at 115 000 bits/second from Jupiter, but satisfactory reception at distances of 6.88×10^8 km at the first encounter with this planet (9.27×10^8 km at the second encounter) may



depend on weather conditions at the Earth receiving station. Rain and other forms of precipitation can seriously degrade reception at X band frequencies, affecting the polarization of the signal, etc.

POWER LEVELS

The 64 m antenna at Goldstone, California, is equipped for radiating power levels up to 400 kW — the Spanish and Australian 64m aerials have 100 kW transmitters. Each of six 26 m stations is operated at 20 kW. Klystrons are used to generate the radio frequency power.

The Viking Mars craft use transmitters of about 30 W power output, the power being obtained from sunlight by the use of solar panels. The Viking craft which landed on the planet can transmit either directly to earth or to the orbiting craft which can relay the signal to earth.

The Venus Pioneer craft will use solar panels to provide over 200 W of power and will be equipped with a number of aerials. The individual probes from the multi-probe craft will be powered by batteries for a short period after they have separated from the main craft and will transmit directly to earth at levels of 10 W to 40 W. However, the data rates will be relatively low owing to the simple aerials used on these probes. Nevertheless, these data rates should be adequate, since no picture data links are needed.

The Voyager Jupiter craft have to be able to communicate with the earth from enormous distances. The intensity of sunlight is inadequate to provide enough power and therefore plutonium 238 radioisotope thermoelectric generators will be employed. Each craft has three of these generators which are 584 mm in length and 398 mm in diameter and which weigh 12.1 kg. Each of these three generators provides 155 W initially, about 135 W after five years and about 125 W after 10 years, but only a fraction of this power is available for the transmitter.

The instruments on Voyager require some 99 W. Voyager will be equipped with a 3.7 m diameter dish aerial which will direct the beam towards the earth; this is the largest dish aerial yet built into a spacecraft.

At Jupiter it is expected that the Voyager craft will provide data rates of up to 115 200 bits/second when used with a 64 m earth station and about 640 bits/second when used with a 26 m aerial. When the craft are in the vicinity of Saturn, the data rate will be limited to about 30 000 bits/second when working with a 64 m aerial and 80 bits/second with a 26 m aerial.

The reason for this is that noise introduces errors. A lower rate enables a narrower bandwidth to be employed and this reduces noise. Errors of about one bit in thirty bits are tolerable for TV pictures, however, errors in command signal transmissions *to a craft* must be far smaller to avoid the craft being sent on an incorrect trajectory. Typically the error should be less than one bit in 100 000 bits — command signal errors can be extremely expensive!

Data rates have greatly increased since Mariner 4 transmitted pictures from Mars at 8.3 bits/second — the increase is about 14 000 over a period of ten years.

SIXTY-FOUR METRE AERIALS

The first of the huge Deep Space Network 64m aerials was constructed at Goldstone, California, part of the design being based on the Australian Radio Telescope aerial at Parkes, NSW; the Goldstone aerial became operational in 1967. Some six years later the Australian 64m aerial at Tidbinbilla (named "Ballima," Aboriginal for "very far away" was brought into regular service, although it assisted with Apollo 17 tracking in 1972.

A 64m antenna collects over six times the signal power compared with the earlier 26m diameter aerials — since the area of a 64m diameter aerial is so much greater. However, other improvements have been made which enable signals of ten times lower intensity to be received than the minimum required by a 26m aerial.

The signal strength from a distant spacecraft is essentially inversely proportional to the square of the distance of the craft from the earth (inverse square law). If a spacecraft at a certain distance produces a signal which is just adequate to be satisfactorily received by a 26m aerial, the same spacecraft will produce a satisfactory signal into a 64m aerial when it is three times farther away. Alternatively a considerably greater data rate can be used with a 64m aerial than with a 26m aerial from the same craft at the same distance.

A 64m diameter aerial is an enormous structure with an overall height of some 73.2m when the aerial is in the horizontal position. The enormous dish must be contoured to an accuracy of ±1 mm even at its edges so that the incoming signals of extremely low intensity are concentrated towards the focus of the huge paraboloidal aerial.

Table 1 shows the enormous weight and dimensions of the Tidbinbilla aerial, but the other two aerials of 64m diameter in California and Spain are very similar. These enormous structures must be able to operate in winds of at least 80 km/hour and withstand gales of 190 km/hour when the disch is stowed horizontally.

The antenna must be able to point anywhere above the horizon. Motors with a total power of some 300kW are used to achieve this. The antenna can be directed to any position in space above the horizon with an accuracy of a few thousandths of a degree, yet the huge structure can completely rotate and be moved from horizontal to vertical in about three minutes. The dish must move so that it continues to point at a spacecraft as it moves across our sky despite earth's rotation. Tracking the spacrecraft is performed automatically by the station equipment.

Signals can be received as soon as the craft appears above the horizon, since the aerial can be pointed in precisely the required direction beforehand. However, the establishment of two-way communications takes longer if the craft is at any distance; for example, a signal sent to a spacecraft in the vicinity of Jupiter will take about 45 minutes to arrive (depending on the position of Jupiter relative to the earth) — a further 45 minutes will elapse before any responding signal can be received back at the earth.

Apart from the 64m or 26m parabolic aerials, each station must have computers, special receivers, analogue and digital processing equipment, black and white and colour television screens, high speed printers able to read engineering data at 80 000 characters per minute and communications equipment plus engineering laboratories, offices, canteens and dormatories which enable it to be self-sufficient. It must also have its own power plant to supply all of the station requirements — one cannot lose signal through power failure when one is performing such expensive experiments. Each station must also have an atomic time generator so precise that it is accurate to one second in 3 000 years.

FUTURE IMPROVEMENTS

In order to improve the facilities of the Deep Space Network, it is hoped to increase the diameter of at least one or the 26m diameter aerials to 34 metres by the end of 1978. The construction of a 100m diameter antenna is also being considered, but as one moves to larger diameter aerials, engineering problems become more and more difficult and expensive relative to the increase in signal strength. The possibility of an orbital relay station in deep space is also being considered. The 64m aerials give a gain of well over one million.

Time standards are vital when one is calculating spacecraft trajectories. Very-long-baseline interferometry techniques are being considered for increasing the precision with which the location of each of the Deep Space Network stations is known.

CONCLUSIONS

The Deep Space Network is a vast engineering project which had to be provided to enable us to obtain information about conditions on other planets and in interplanetary space. Although most of the work of planetary exploration has been carried out by Americans, Australia has provided a very substantial contribution to this work. There will be an increasing demand on the Network during coming years for higher data rates from more distant planets.

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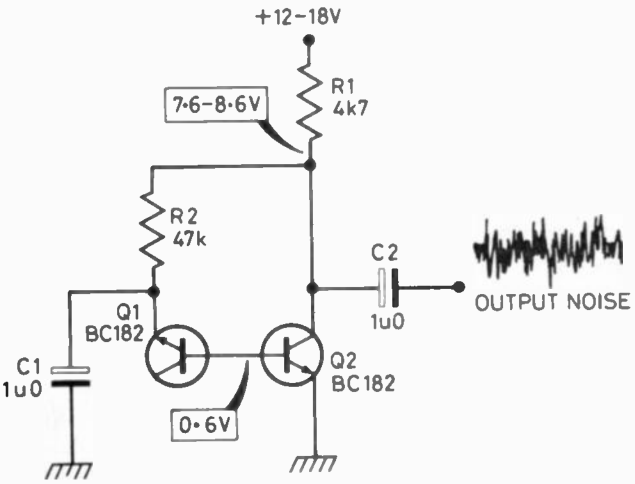
Short Circuit

TWO — TRANSISTOR NOISE SOURCE



This simple circuit produces electrical noise. This may not seem like a senisble thing to want to produce, but in fact it is very useful. Of course, the sort of noise we mean is not the type neighbours complain about. This circuit produces an electrical signal which, when suitably amplified, sounds like a hiss of escaping gas. This can be used for sound effect production — with a little additional processing, it can form the basis of sound effects ranging from surf hitting a beach to a steam train — or for testing loudspeakers by feeding the amplified noise into them and listening to the output.

The operation of the circuit depends on the reverse-bias breakdown of Q1. This occurs when the voltage across the emitter and base of the transistor reaches 7 to B volts. At this voltage the semiconductor physics of the transistor cause it to do a very useful thing — produce noise. The rest of the circuit is dedicated to keeping the current throug h Q1 to just the right level (too little — no noise; too much — dead transistor!) and also to amplifying the result.

Power is suppllied to the circuit through R1. This, along with C2 and Q2 form an amplifier which boosts the level of the noise. The bias for Q2 comes through Q1. If Q1 passes a lot of current, Q2 will turn on more and the voltage at the bottom of R1 will drop. This will cause the voltage accross Q1 to drop and the current through it will decrease. In this way the current it passes is kept to a reasonable level. C1 provides a path to earth for the noise which appears on the collector of Q2. This ensures that the fast changes in the amount of current through Q1 (and this is, after all, what we are after) are not 'adjusted' in the same way and lost.

Photon Phone

The PHOTON is a light-talker: a communications system which requires no licence.

THIS IS NOT a morse flasher. This is the equivalent of a two-way radio — but using light instead of radio waves!

All a radio transmitter is, is a source of radio-frequency signals and some means of impressing information onto it. This project uses light, and as a source of light we use — you guessed it — a light bulb!

This project should provide not only an introduction to photoelectronics but also a product which is fun to build and use and (as far as we know) is unavailable commercially in any but a military form.

USING IT

The device is almost as easy to use as a radio — you point your set at the one you want to communicate with; you switch to 'transmit'; with the other set at 'receive', anything you say into the built-in microphone will be heard, via the light beam, at the other set. Reversing the switch positions allows full two-way communication.

The range of the device is limited to about 15 to 20 yards but for many applications (at sea, in a factory, between moving vehicles or just across the street!) this will be sufficient.

The electronics is easy to put together — the only difficult bit is the case.

CONSTRUCTION

The torch body we used can be seen in the various photos in this article. It is made by Ever Ready and should be fairly easy to come across.

The first thing to do is to open it and remove the battery connectors in the inside of the top cover. We need the room and we're using a different type of battery anyway. You will find that these come out with a small amount of force — try not to damage the plastic.

The next thing to do is to take the bulb out and replace it with one of the same size and shape but of a different voltage (see the parts list). You will probably be able to get this at the same place you got the torch body. Now solder the wires onto the OCP71 phototransistor, as shown in the overlay (the diagram which shows you what goes where on the board). Clip the unused (middle) wire short. The diagram shows a view looking onto the end of the wires. Take care not to damage the transistor by excessive heating — it's a good idea to hold the wire you're soldering at a point between the joint and the transistor with a pair of long-nosed pliers while the joint is hot. This will prevent heat from getting into the transistor body. Insulate the wires in some way (Sellotape will do at a pinch).

Having done that, fit the phototransistor (Q2) onto the bulb as shown in the photo. We used a quick-setting epoxy resin adhesive. You will have to make a small hole in the reflector for the wires to go through. Try to get the transistor as close to the focal point of the reflector as possible. This means mounting it at the very tip of the bulb.

Looking closely at the inside of the torch, you will find that the metal strips which form the normal torch circuit pass from the battery holders (or rather, where the battery holders were until we ripped them out!) up the hand to the switch and then back down to one side of the bulb assembly. Cut the connection between the switch and the bulb. This will probably mean a little minor metalwork with a pair of wire cutters. It should leave you (it is possible to trace the connection path fairly clearly with a little thought) with two connections to the bulb and two to the switch. Solder wires onto all four of these points. Leave the wires fairly long (6 to 8") for future connection to the board.

START AT THE BOTTOM

The speaker fits into the base of the case (poetry, yet! — ED.) at the back. This means that you can either drill an artistic pattern of holes as we have done or just put a few large ones as you think fit. If you don't put any holes at all, the sound won't get in or out.

It's probably a good idea at this stage to solder a couple of wires onto the speaker and glue it into place.

The only thing left to do now is to fit the extension speaker socket (the method should be fairly self-evident from the socket mounting), as the other holes in the case should really be matched with the printed circuit board.

BOARD MEETING

Having 'acquired' a printed circuit board (see the DIY PCBs article in this issue), fit it into the top of the case (making sure you get it the right way round) and mark out the rest of the holes to be made in the case:

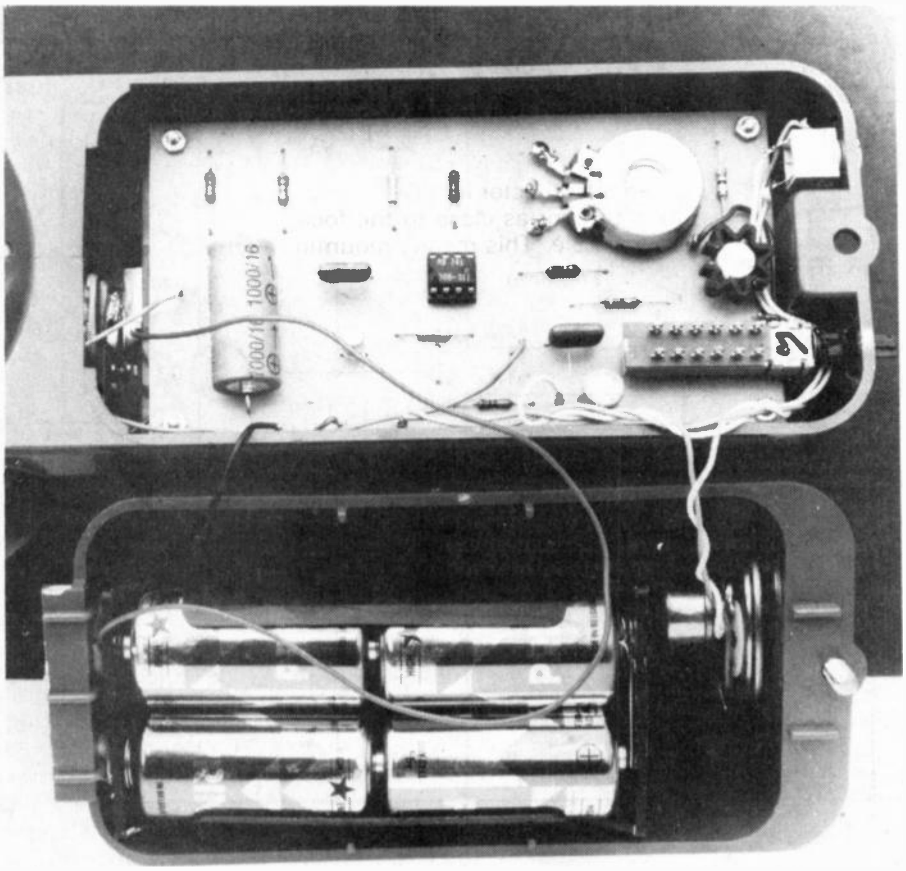
a) the four PCB mounting holes,
b) the volume control (RV1) hole and
c) The SW2 hole (make this big enough for the push-fitting knob).

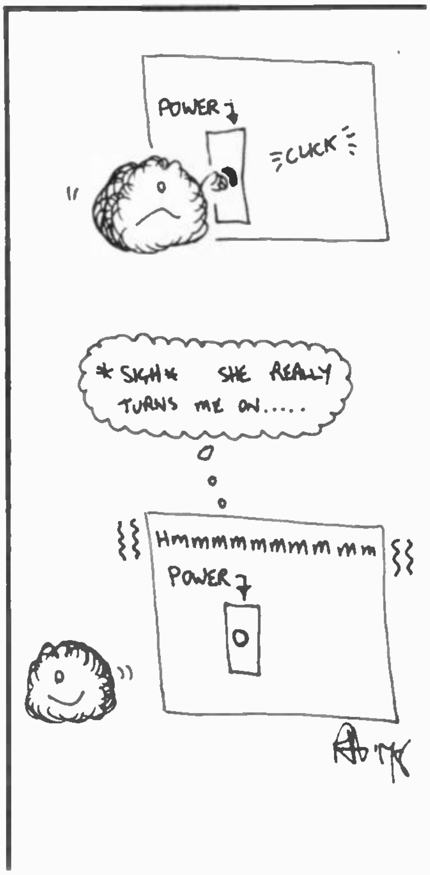
The construction for the electronics should be fairly straightforward — just follow the diagrams. Watch out that you get C1, the transistors and IC1 the right way round, though. We suggest you use an integrated circuit socket for IC1 — solder it onto the board and then plug the IC into it, making sure all the 'legs' go in. Use a heatsink on Q3. This acts in exactly the same way as a car radiator — it carries the heat into the air, preventing the transistor from overheating.

At the points where wires from the bulb, speaker etc. are to connect to the board, poke stiff wire through and board and solder it, leaving about ½in sticking above the board. This will allow you to solder wires on the board *after* it has been bolted down. You will have to use similar bits of wire to connect RV1, as the leads on this will not poke through the holes.

If possible, use a 'lash-up' at this stage — a collection of bits of odd wire connecting the board to the various other bits of the circuit — to check that the board works before you bolt it in.

A view of the reflector modifications. The transistor should be placed with the small metal dot (just visible inside the protective gel of its case) towards the rear of the communicator. Some experimentation may be necessary to find the reflector's focal point exactly.





BOLT IT DOWN

Use pillars on the four PCB mounting bolts. These are plastic or metal cylinders which slip over the first ¼in or so of the bolts and will hold the board away from the top of the case.

Actually getting the board in is a bit fiddley — but remember that you can always push SW2 in to get it out of the way. It might also be an idea to trim the spindle of RV1 a bit before you mount the board — not too much, though remember you don't know exactly what length it should be until *after* the board is fitted!

Having fitted the board and both of the knobs (SW2 and RV1), you can proceed with the wiring.

The only complicated bit is the wiring of the external speaker socket and the speaker. Connect the 'speaker' point on the board to one side of the speaker and also to the connection on the side of the socket. The 'socket' output of the board goes to the socket connection which is part of the sprung contact of the socket (put a plug into the socket — the bit of the socket that moves is the bit you want). The third socket connection goes to the other side of the speaker. Got all that?

If you're confused, just connect the speaker to the two board outputs mentioned to make sure it all works. You can connect the socket up later.

The battery holders should be connected in series: the "+" connection of one goes to the " — " connection of the other.

The remaining "+" connection goes to the handle switch (SW1 — remember those wires you connected earlier?) and the other side of the switch goes to the board.

The circuit diagram. SW2 is shown in the 'transmit' position.

How it Works

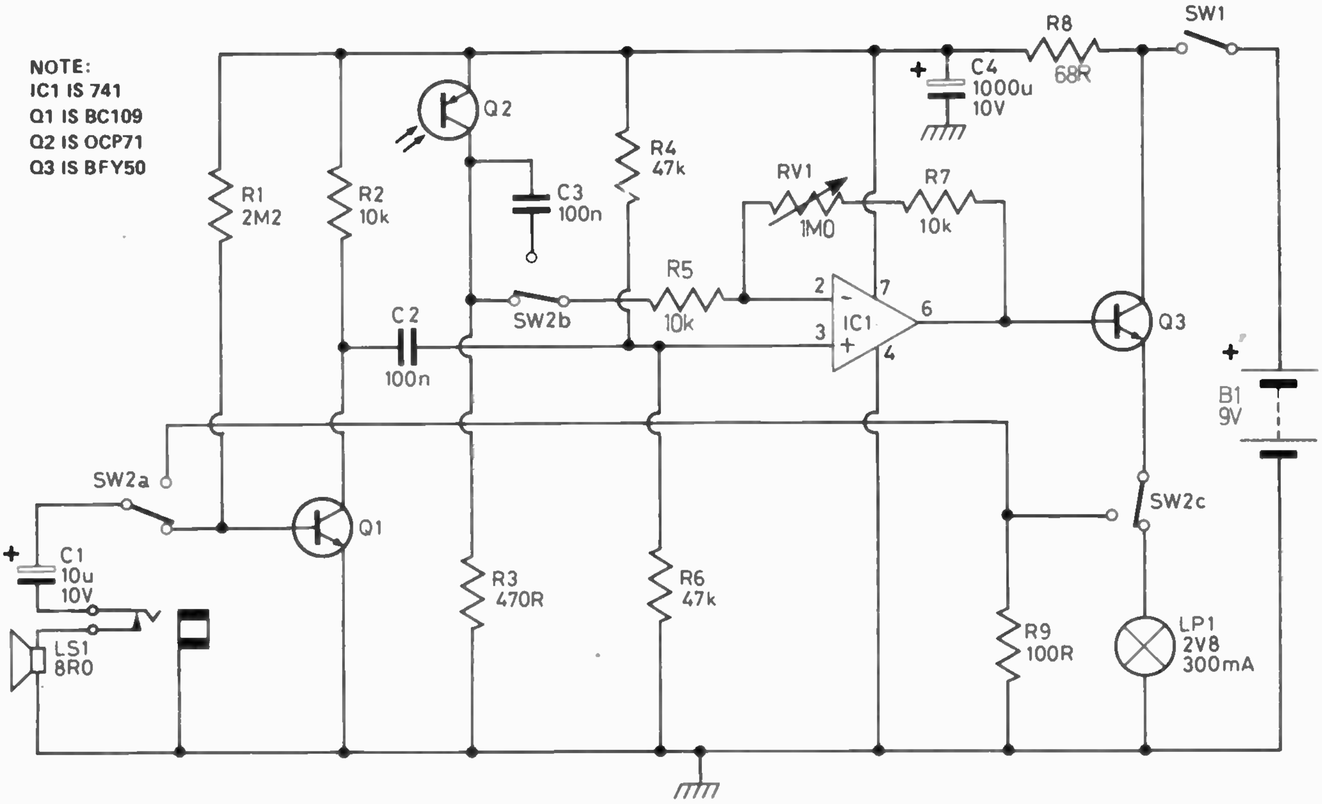
The circuit diagram shows SW2 in the 'transmit' position. The speaker (LS1) acts as a microphone in this mode. C1, R1, Q1 and R2 form a simple single-stage amplifier to boost the signal before it is fed, via C2, to IC1. R4, R6 and C2 set the average voltage at pin 3 of IC1 (the so-called 'bias' voltage).

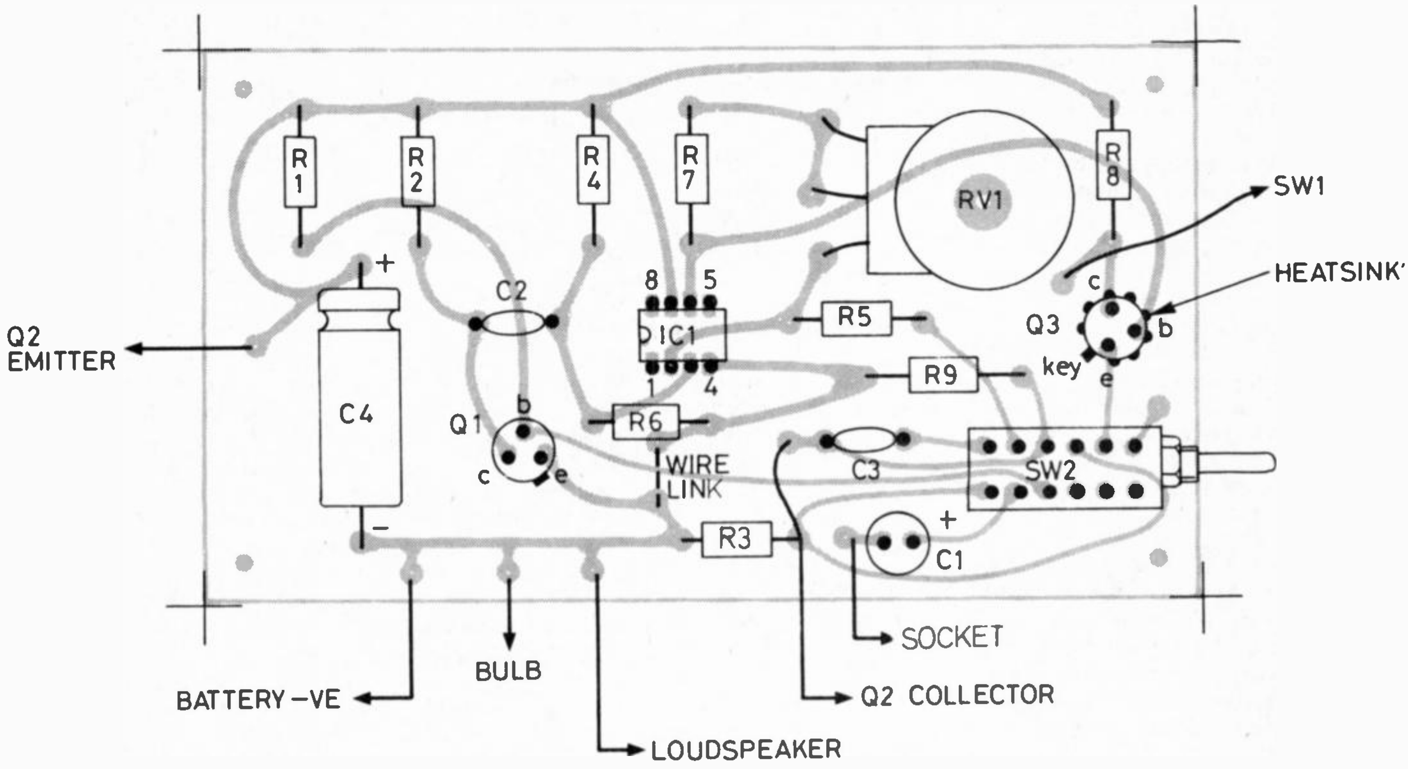
For a detailed description of what Q2 is and does, see the 'photocells' feature in this issue. Q2 is illuminated by LP1. Suppose LP1 is bright. This will cause more current to pass through Q2 and cause pin 2 of IC1 to go to a higher voltage. IC1 is connected as an inverting amplifier (in much the same way as the op-amps in the 'mixer' project in this issue) and so this will cause the output (pin 6) to fall in voltage. This in turn will turn Q3 down and the current through LP1 will reduce.

All in all, the effect will be to set LP1 at a brightness determined by the pin 3 input of IC1. As this is derived from LS1, speaking into it will cause a brightness fluctuation.

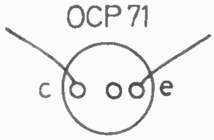
In the 'receive' mode, the light variations at Q2 will cause a voltage variation in the output of IC1. This is used to drive Q3 which is now connected to LS1.

Notice that the rest of the circuit is 'decoupled' from Q3 by R8 and C4. As this device is battery-driven, the current drawn by Q3 will cause major variations in supply voltage. So that these do not interfere with the rest of the circuit's operation, they are filtered out by R8/C4.





How to position the components on the PCB, make sure the transisters, intergrated circuits, diode and electrolytic capacitors are the correct way round before soldering in place.



Parts List

RESISTORS

R1	2M2
R2	10k
R3	470R
R4,6	47k
R5,7	10k
R8	68R
R9	100R

CAPACITORS

C1	10u 10V electrolytic
C2	100n polyester
C3	100n polyester
C4	1000u 10V electrolytic

SEMICONDUCTORS

Q1	BC109
Q2	OCP71
Q3	BFY50 + heatsink
IC1	741

MISCELLANEOUS

RV1	1M logorithmic
LS1	8R, 2 inch
SW2	4 pole 2 way, latching, PCB-mounting switch
LP1	2V8, 300mA

Ever Ready torch; two 4 x HP11 battery holders; 3.5mm earphone socket + matching plug; IC socket.

Most of the components for this project will be available by mail order from advertisements in this issue. The OCP71 is available from Watford Electronics, (33 Cardiff Road, WATFORD, Hertfordshire) for £1.54 inclusive of VAT and P&P.

You should be able to get the torches and bulb from most large department stores.

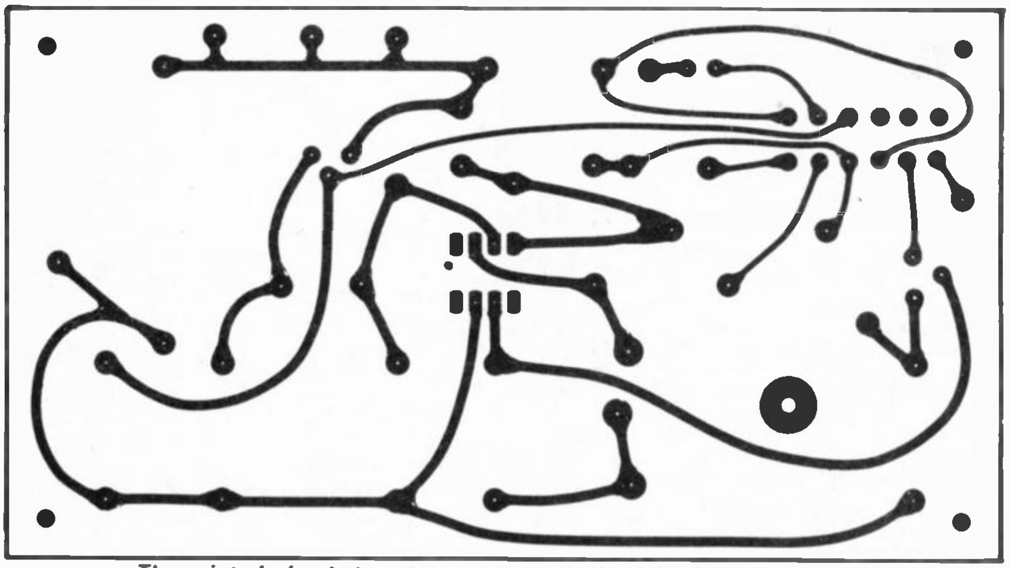
Approximate Cost: £9 per unit

Connect the rest up as per the diagram, and the whole thing should work! If it doesn't, check all the wiring carefully.

SPOCK TO ENTERPRISE . . .

With the sets switched on and the SW2s to the relevant positions (one in, one out) point the two devices at each other at a distance of a couple of yards. Speaking into the speaker of the one switched to transmit (SW2 out), you should be able to see the light intensity varying and a well-placed ear beside the receiving set should be able to hear your voice. (Needless to say, it will not be your ear if it's your voice two yards away!). The volume of the received sound can be adjusted by RV1 to give a pleasant level.

You may find that putting your ear to the speaker while pointing the device is a bit tiresome after a while. This is where SK1 comes in. A speaker similar to the one already used can be connected across a suitable plug and inserted into the socket. This has the same effect as plugging an earpiece into a radio. The internal speaker is 'disabled' (temporarily!) and the hand-held one is used

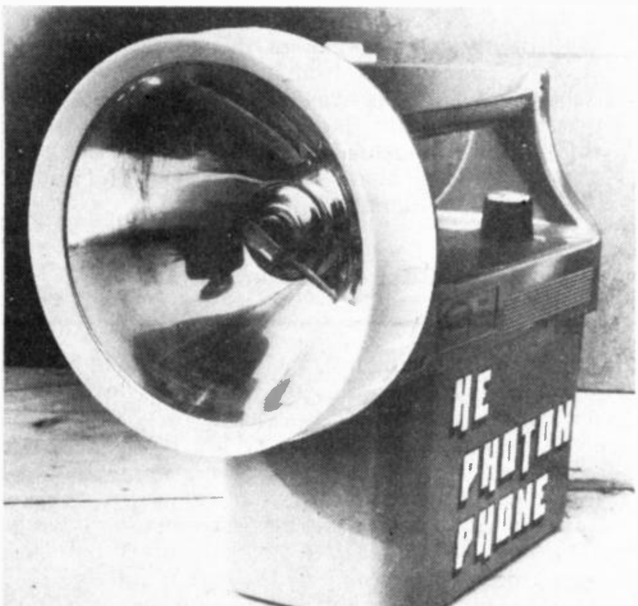


The printed circuit board pattern shown here is the correct size.

instead. Putting the external speaker in a small box is a good idea, as is using 'screened' cable for the connecting lead. The centre of the cable goes to the tip connection of the plug.

SUMMARY

This project is difficult to build as a finished product and the fact that two (at least!) are required may seem daunting. However, it can also be built as a "bread-board' type prototype, or into any type of box you can get your hands on. If you do build it as we suggest, though, you will have a very sturdy product indeed. HE



A rear view of the PHOTON, showing the artistic pattern of holes we drilled to form the speaker grille!

The business end. Note how the phototransistor is mounted.

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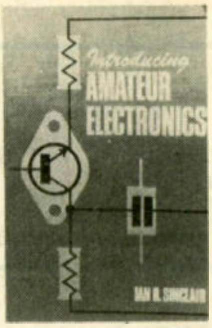

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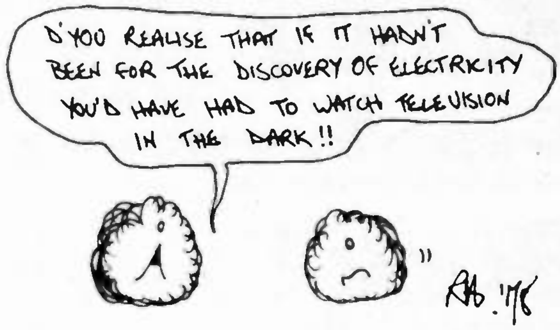

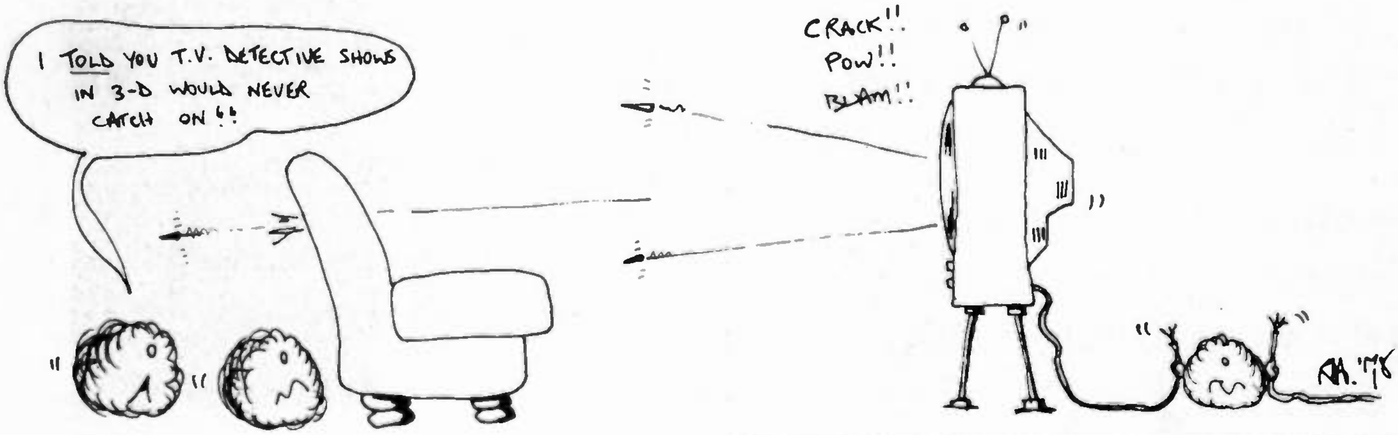

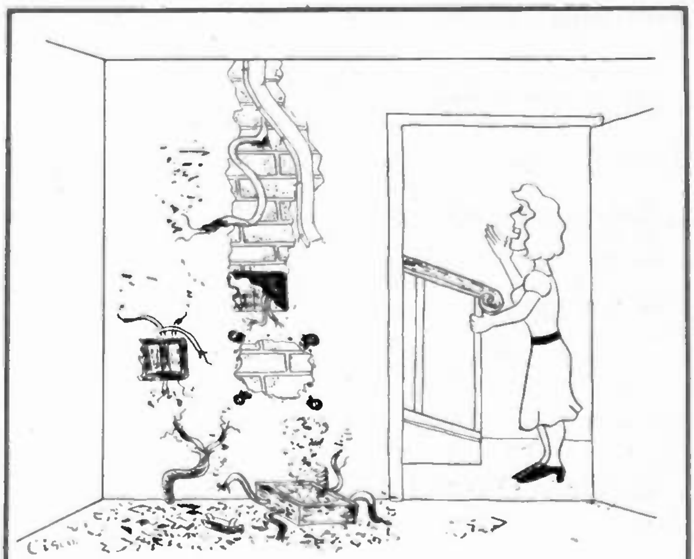

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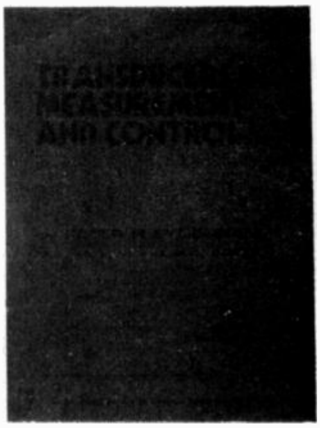

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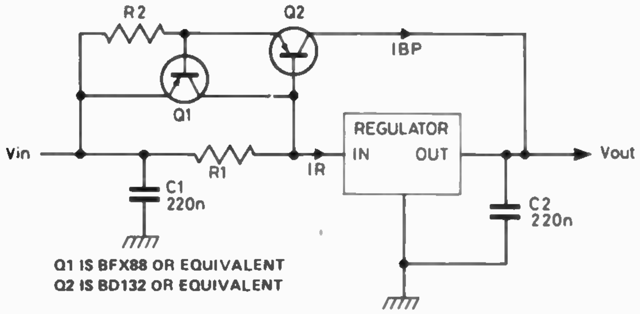
Short Circuits



REGULATOR BOOSTER

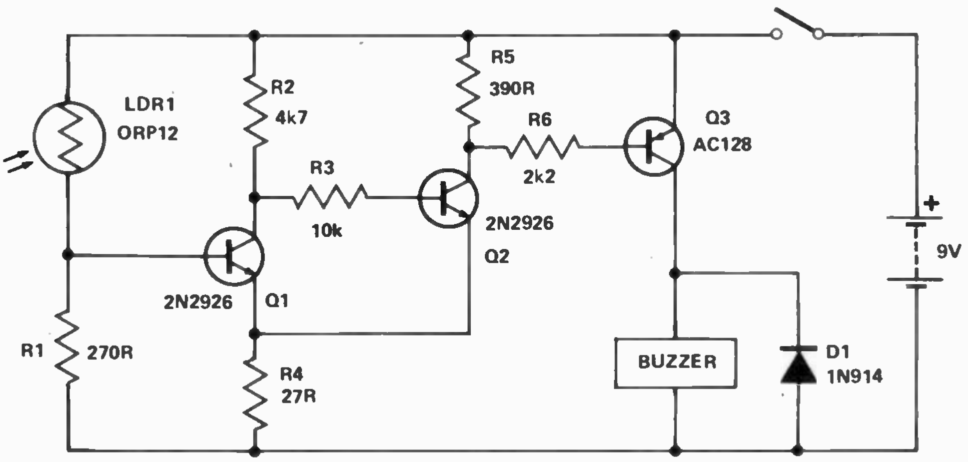
If you've ever been in the unfortunate position of having a regulator in a piece of equipment which will supply, say, 0.5 A and you find that, for one reason or another, the equipment needs to draw 2A then this little circuit may save the day.

Essentially, it consists of a transistor which will switch on at a certain current flow into the regulator and bypass it to an extent. In its operation it is similar to a 'current dumping' amplifier. The transistor will pass a large amount of current without regulating it and the regulator will do all the fine tuning to make sure the output is stable. The circuit also includes a second transistor (called Q1 here because it appears at the left of the diagram!) which will limit the current through the power handling one to protect it during a short circuit of the output. During a short circuit, the regulator will presumably look after itself.

The operation of the circuit is fairly simple. As soon as the voltage drop across R1 is greater than the minimum bias voltage for Q2 (0V6), Q2 will turn on. As R1 is a 1 ohm resistor, this will occur when 0.6A is passing into the regulator. Having switched on, Q2 will supply current directly to the load. The regulator will sense it's output voltage and if (as is likely, since the current through Q2 will be un-regulated) the output voltage is now not what it should be it will pass or hold back current as required and so the output will be stable and set at the regulator's output voltage. The two capacitors are necessary to prevent the whole thing from going into a frantic oscillation as the regulator and Q2 try to decide who is doing what.

If the current through R2 rises above that needed to provide a 0V6 drop across it, Q1 will switch on and short out R1, thus removing the bias from Q2. This will prevent Q2 from passing more current than is good for it. Q2 should be mounted on a heat sink to prevent it from glowing red hot.

LIGHT SENSITIVE SWITCH



The controlling factor for this whole circuit is the light dependent resistor LDR1 type ORP12. This has the property of having a very high resistance in complete darkness (over 1MO) but in the brightest light this falls to nearly 300R (although individual devices vary greatly).

At first sight it would seem possible to use the ORP12 only, to control the circuit but this has several disadvantages including the fact that the current passed through the device must be kept low.

For simplicity the circuit will be described for 'dark on' using a directly lit LDR.

When daylight is falling on the ORP12 the resistance is fairly low — the actual value is not important but it will probably be in the range of 300R to 3KO. With R1 the two components form a potential divider with the base of Q1 connected to the junction. If the resistance of the ORP12 was high the voltage at the junction would be low but since we are discussing the circuit with the voltage at a reasonable level Q1 is biased on — that is, it is in a conducting state. In this condition the voltage across the transistor is small and since Q2's bias depends upon this voltage, it is therefore held off and following the chain of R5 and R6 it will be seen that the base of Q3 is connected to the positive supply, and is therefore non-conducting.

As the light level falling on the ORP12 gets less and less, the voltage at Q1 base falls, until it reaches such a level that Q1 tends to conduct less. As the current through Q1 fails, the voltage drop across it increases, and this starts to bias Q2 into conduction.

As Q1 and Q2 share the same emitter resistor there is a regenerative action. Q2, by becoming conductive, raises the voltage on the transistor side of R4 and since the base voltage on Q1 is still at the same level this biases Q1 even more into non-conduction.

The switching action is extremely rapid once it has started and the overall effect is that although the voltage at the base of Q1 is only changing gradually and slowly, Q2 is switched completely on at a certain point, and Q1 is switched off.

The circuit configuration just described is known as a Schmitt trigger and has a number of applications in several fields of electronic switches.

When Q2 is switched on, the voltage at the collector falls and Q3 is biased into full condition through R6. With Q3 on, current is passed through the buzzer.

A relay can be used in place of the buzzer — its coil resistance hardly matters and does not upset circuit conditions. However, relay coils, when used with transistors, should always be by-passed with a diode. The reason for this is that when the relay is switched off a back voltage of very high level is created which can destroy the controlling transistor. The diode, however, safely shunts this to the negative line and so protects Q3.

A 'dark off' (or 'light on') circuit can be made by reversing the ORP12 and R1 — which now becomes 33k. In this condition Q1 is on but as the light level increases the voltage at the base of Q1 falls and the same action applies as before.

R1 in both versions of the circuit can be replaced by a variable resistor, and this enables the light level at which the circuit triggers to be varied.

Note that Q1 and Q2 are silicon N-P-N types whereas Q3 is a germanium P-N-P type. Q3 passes quite a large amount of current and can be destroyed unless a heat sink is used — one of the fin types which clip over the body should be adequate.

When Q3 is off the current consumption is very low — about 4mA and this will be little drain on a battery.

Into Electronics

by Ian Sinclair Part 2

In this second part of our major series which covers electronics along the O/A level syllabus we look at passive components and how they behave in electronics circuits. Block diagrams are also explained.

IN A COMPLETE circuit, DC current in the form of moving electrons can flow around the circuit, pushed by the EMF (electro-motive force). If the current is AC, the electrons never flow right round the circuit, but only dance to and fro, moving in one direction when one end of the circuit is positive, and in the other direction when the EMF reverses. As we've seen, it doesn't matter to a resistor whether the electrons move steadily or to-and-fro, the power is converted into heat anyway. For some other components though it matters a lot. For example, a moving-coil meter simply cannot cope. The coil and needle cannot reverse direction more than a few times per second, so that for AC of 10Hz or more, the reading is effectively shown as zero.

Other components behave differently think of a circuit with a break in it. Because electrons won't move across the gap, there is no steady current. When the EMF is alternating, there is still some movement of electrons in the rest of the circuit. With the EMF in one direction one end of the gap is positive, the other end negative. When the EMF reverses, the polarity across the gap must also reverse.

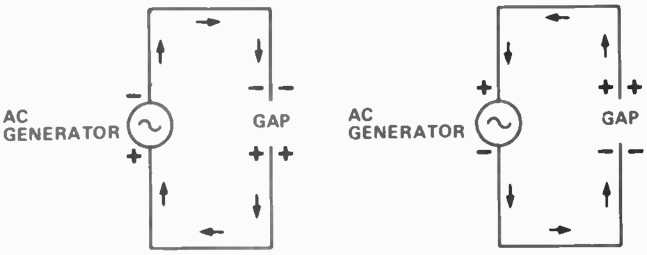


Fig. 1. An alternating EMF will cause a to-and-fro movement of electrons even if there is a break in the circuit. Each time the EMF reverses, electrons must move along the wires as far as the break.

Now for this to happen, some electrons have to move. For one end of the gap to be positive and the other end negative, electrons have had to move from the positive end to the negative end (remember that the electron is negatively charged). When the voltage reverses, the electrons have to shuffle around in the opposite direction. Even with a gap in the circuit, then, there can be some to-and-fro movement of electrons, the type of current we call alternating current.

You could call a capacitor a carefully designed gap in a circuit. Like any other gap in a circuit, a capacitor does not allow steady current to flow, but it will allow electrons to accumulate on one side and drain on the other side of the gap. The first capacitors were made in the shape of jars (because it was thought that electricity was a liquid!) with gold leaf on the inside and also (but not electrically connected) on the outside. Later, metal plates separated by an insulator (known as the **dielectric**) were used. Nowadays, we use paper or plastic insulators coated with metal film each side but we still talk of "plates", and the symbol for a capacitor (Fig. 2) shows two plates separated by a gap.

Fig. 2. Symbol for a capacitor. This symbol is used for a fixed capacitor, meaning a capacitor whose value is not deliberately changed (as for tuning a radio). A slightly different symbol is used for an electrolytic capacitor.

It's not so simple as a gap in the circuit, though. The greater the area of these plates, and the closer they are to each other, the greater the number of electrons that have to be shifted from one side to the other to create a voltage across the plates. Even the type of material that lies between the plates can affect this number of electrons. In electronics language (parliamo electronico?) a lot of charge has to be shifted to get a voltage across the plates. The ratio

$$\frac{\text{amount of charge}}{\text{amount of voltage}}$$

is called **capacitance** and is measured in units called **farads** (abbrievated F). A large amount of capacitance means that a lot of charge has to move to give one volt between the plates, a small capacitance means that only a small amount of charge needs to move to obtain the same one volt between the plates of this device called a capacitor.

We boobed a bit with the unit, though. Using the definition

$$\text{capacitance} = \frac{\text{charge}}{\text{voltage}}$$

and using the units of coulombs for charge (the coulomb is the amount of charge that moves when one ampere flows for one second) and volts for voltage, the unit of capacitance, the farad, is the coulomb per volt, and it's miles too big for practical purposes. We have to make use of the sub-multiples micro-, nano- and pico- when we work with capacitors, so that values such as 10uF, 2.2nF (written as 2n2) and 100pF are the sort of values we are likely to see and use.

The way we make capacitors depends on the sort of values we need. For the smallest pF (picofarad) sizes, we can use small discs or rectangles of insulators, such as silver-mica, coat each side with metal, then make contacts to the two separate metal layers. For larger values, a few nF perhaps, we can pile these plates on top of each other, separated by uncoated plates for insulation, and connect alternate sides together (Fig. 3b).

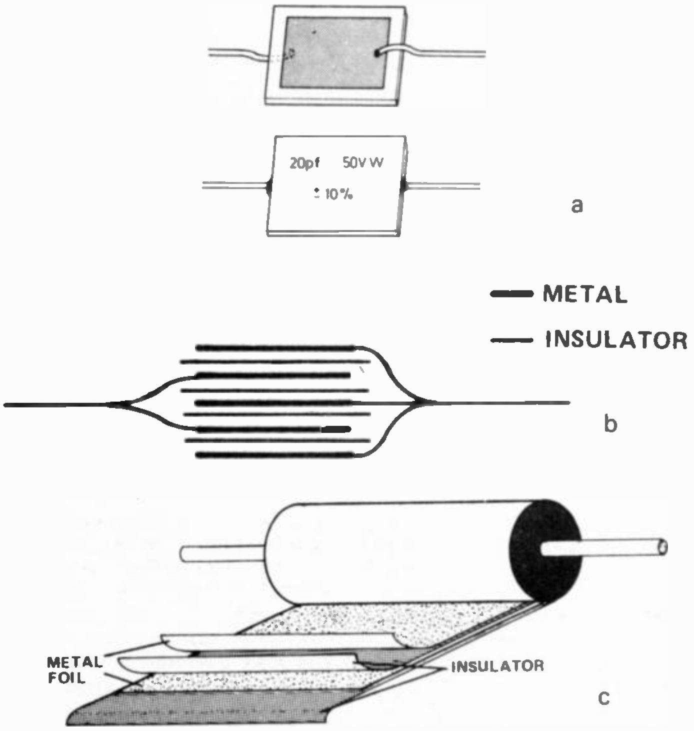


Fig. 3. Some practical methods of construction. a) Single metallised plate. b) Multiple plates — showing plates separated, with interconnections, before pressing together and covering with plastic coating. c) Rolled paper or plastic construction.

When we get to values of 10nF or more, an easier construction is to use a ribbon of paper or plastic, metallise each side, then roll the ribbon up along with an unmetallised ribbon to make sure that the metal surfaces do not touch; this gives the tubular capacitor. For values of 1uF upward, even this construction is too bulky, and electrolytic capacitors, constructed like dry cells, are used. The insulator here is a thin film of hydrogen gas, so thin that it will be damaged by having too great a voltage across it. Electrolytic capacitors can have very large capacitance values in a very small size, but work only at comparatively low voltages, and must be polarised.

Polarised? Yes, like a battery there's a + and a — connection to an electrolytic, and the markings must be observed, with the + lead always connected to a higher positive voltage than the — lead. Get these reversed and, at best your circuit will not work, at worst you will have the corrosive paste from inside the capacitor sprayed all over you!

INDUCTORS AND TRANSFORMERS

If a gap in a circuit can become a circuit component for AC signals, what else is in store? Watch this space for the curly wire trick. Take a length of wire, connect it up in a DC circuit, find its resistance. A few ohms, perhaps? Fine, now coil the wire up, and find the resistance. Just the same, you find. Do all this with an AC circuit, working at high frequency, and you find that coiling the wire up has a very great effect on the current, just as if the resistance had increased.

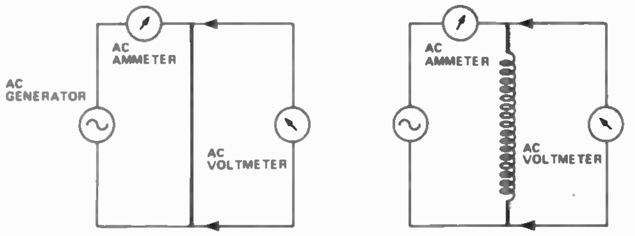


Fig. 4. The curly-wire trick a) In an AC circuit a straight wire with low resistance has only a small voltage across it. b) Coiling the wire has the effect of making it behave like a higher resistance, so that the voltage across the wire is greater. This would be noticeable only when the supply frequency was fairly high.

It's no mystery, really. Coiling the wire up makes it an electromagnet when a current flows, and when the current reverses, the direction of the magnetism has to reverse also. It needs a bit of energy to do this though, so that passing an alternating current through such a coil, called an **inductor,** is not so easy as passing the same current through a straight wire or passing DC through the coil. The size of this effect is measured by a quantity called **inductance,** measured in units called **henries** (Mr Henry was an American physicist who died in 1878). As usual, we make use of submultiples like millihenries (mH) and microhenries (uH), though it is possible to make coils of several henries of inductance.

Because inductance is caused by magnetism, winding a coil of wire around a magnetic material, such as soft iron, makes the amount of inductance very much greater than that of the coil alone. Materials like soft iron concentrate magnetism, and it's this effect, called **permeability,** that makes a coil with an iron core have so much more inductance than a similar coil with an air core. For two similar coils, the addition of a magnetic core can make the inductance value many *thousands* of times greater.

Iron cores are less useful, though, when the currents through the wire in a coil are high-frequency signals, because then too much energy is wasted in magnetising and demagnetising the iron. Inductors intended for use with high frequency signals must use air cores or special materials called ferrites.

That's not the end of the tricks we can play with coils, though. Suppose we wind two separate coils, insulated from each other, on to the same magnetic core. Connect one coil to an AC circuit and pass AC current through the coil. This will magnetise the core, but the magnetism will be alternating, changing direction as the current changes direction. Now for the crunch — the alternating magnetism will generate alternating EMF in the other coil. We can use this other coil as if it were a generator of alternating EMF — which it is. This arrangement is called a **transformer.** The coil which is used to create the alternating magnetism is called the primary coil, and the coil which has the EMF generated in it is called the secondary coil.

The reason for the name, transformer, is that the voltage that comes out of the secondary coil isn't necessarily the same as the voltage across the primary coil. We put an alternating voltage, a sine wave, across the primary winding, and we get an alternating voltage, a sine wave with the same frequency from the secondary winding, but the voltages don't have to be the same. In fact the voltage at the secondary depends on the number of turns in each of the two coils as well as on the primary voltage. The law of the transformer is $Vs/Vp = ns/np$; where ns is the number of secondary turns, np is the number of primary turns, Vs is the secondary voltage, Vp is the primary voltage.

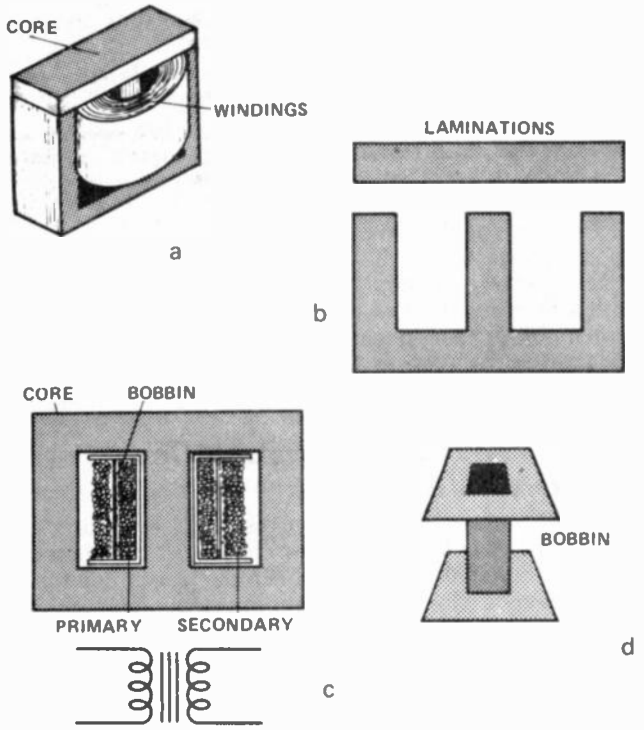


Fig. 5. The transformer. a) General appearance, b) Core and bobbin, c) Sectioned view, d) Symbol.

For example, if we have a transformer with 5 000 turns of wire for a primary winding, and a 250V AC supply, what voltage can we expect across a 500 turn secondary winding? The equation is $Vs/Vp = ns/np$, and filling in values we get $Vs/250 = 500/5\,000$; so that $Vs = 25V$.

This we would call a **step-down** transformer, because the secondary voltage is less than the primary voltage. We could just as easily make the secondary winding have a greater number of turns, so that the transformer is a **step-up** transformer.

None of this happens when DC is used. Slap some DC through a transformer and all you get is a hot transformer, a smell of burning and a few blown fuses. DC will magnetise the iron core all right, but it won't cause the alternating magnetism that makes the thing work. Worse still, because the resistance of the wire used for transformer windings is low, far too much current will flow through the wire if DC is used. Transformers are strictly AC devices.

JOINING THEM UP

In a circuit, components like resistors, capacitors and inductors can be connected together. Before we look at what happens in such circuits, let's see what the effect is of joining similar components together. There are two ways of connecting components, in series and in parallel. In a series circuit, the same current flows through the components, one after the other. In a parallel circuit, the same voltage is across each component, though the currents can be different.

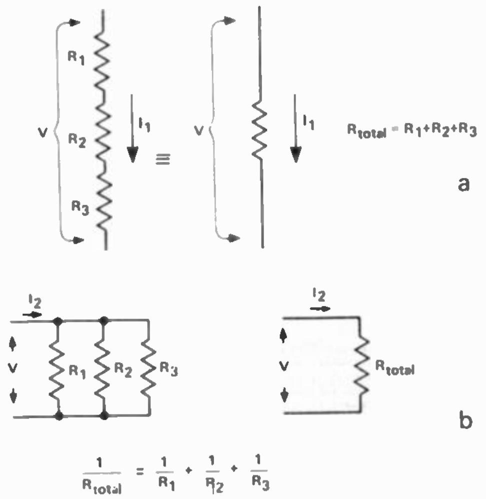


Fig. 6. Resistor circuit connections. a) In series. Total resistance means the resistance value which would have the same voltsge across its terminals for the same amount of current passing through it. b) In parallel. Using the same definition of total resistance leads to the formula shown.

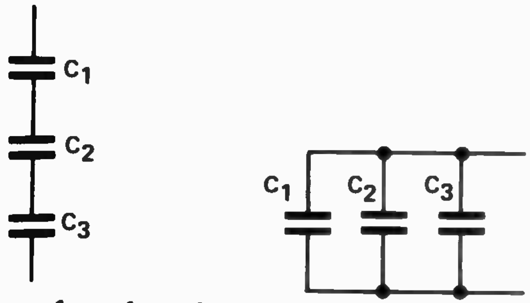
Connecting resistors in series has the effect of increasing the total resistance, as we might expect. Formula. $R_{total} = R_1 + R + R_3$ . . . for as many resistors as we have connected in one series circuit with the same current flowing. For example, a 6k8 resistor in series with a 2k2 resistor gives a total of $6.8 + 2.2 = 9k$. This is a value we can't obtain in the usual 10% series and this is one use of series connections. A more valuable application is the potential divider shown in Part 1 of this series.

Connecting resistors in parallel makes the flow of current easier because there are several paths for current now. Formally, $1/R_{total} = 1/R_1 + 1/R_2 + 1/R_3$ for as many resistors as are connected in parallel across the same voltage. For example, a 30R resistor connected in parallel with a 20R will give

$$1/R_{total} = 1/20 + 1/30 = 5/60$$

$$\text{so that } R_{total} = 60/5 = 12R.$$

This is the value of the resistor which could replace the 20R and 30R in parallel. Note that two identical resistors in parallel produce a total resistance equal to half the value of each resistor, three in parallel are equivalent to a resistor of one third of each resistor value and so on; for example, three 3k3 resistors in parallel give 1k1. Parallel connections are very useful for reducing or trimming resistance values down to the size we want. For example, if we want to use 6k and we have 6k8, we must add a resistance R so that $1/6 = 1/6.8 + 1/R$. Producing the old calculator and going through the steps we find R=51k. (The nearest preferred value is 47k.)



$$\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \qquad C_{total} = C_1 + C_2 + C_3$$

Fig. 7. Capacitor connections — the same formulae apply, but they apply to the opposite connections. The simple addition formula applies to parallel capacitors, the inverse formula to the series connection.

Inductors obey the same laws — adding the value for series connections, and using the reciprocal rule for inductors in parallel. Capacitors, just to be awkward combine the other way round. Connecting capacitors in parallel is like adding their plate areas, so creating a larger capacitance. For capacitors in parallel

$$C_{total} = C_1 + C_2 + C_3 \ldots$$

Capacitors in series behave like resistors in parallel, so that

$$1/C_{total} = 1/C_1 + 1/C_2 + 1/C_3 \ldots$$

TIME CONSTANTS

All a resistor can do is to dissipate power, converting it to heat. Capacitors and inductors can store energy and give the stored energy back again, but both need some time to act. The thing to remember is that we can't *instantly* change either (a) the voltage across a capacitor or (b) the current through an inductor. Take for example, the capacitor and resistor in Fig. 8. Switching on causes the voltage of plate (1) of the capacitor to rise from 0 to +9V. Because of the instant change rule, the voltage of the other plate (2) is also 9V at switch-on. It can't stay at the voltage, though, because current will now flow through the resistor — this is the movement of charge that is needed to charge the capacitor. When the charge has stopped moving, plate (2) voltage is zero and the capacitor is fully charged. The time constant for this arrangement is given by C (in farads) × R (in ohms), result in seconds. Because of the shape of the graph of

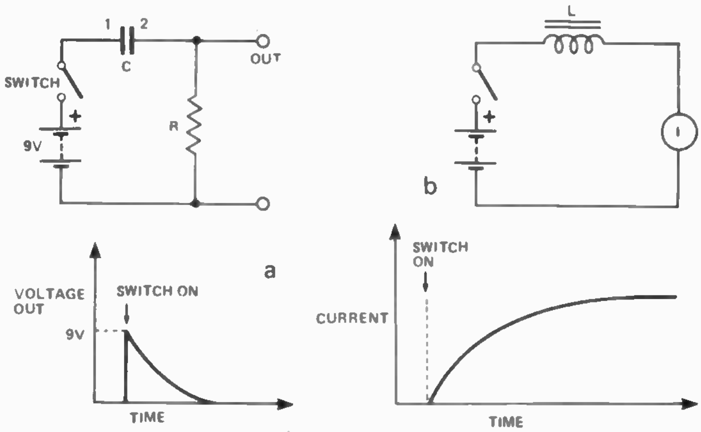


Fig. 8. Time constants. a) A capacitor and a resistor connected together have a natural time constant equal to CR seconds. In the graph of voltage against time that is shown here, the time constant is the time after switch on for the voltage to reach 37% of the battery voltage. b) An inductor has resistance R (because of the wire it's made from), and its time constant is L/R. The time constant of an inductor causes a delay in reaching a steady value of current when a voltage is applied across the capacitor. The time constant in this circuit is equal to the time taken, after switch on, to reach 63% of the final current.

voltage plotted against time, the figure of time constant is not the time for the voltage to each zero but to fall to 37% of its starting value. In this example, the time constant is the time taken for the voltage to reach 37% of 9V, which is 3.3V. The point is that the greater the value of this time constant (great capacitance, greater resistance, or both) the longer it takes for charging to be complete.

The same applies to current in an inductor. Switching on a voltage across a large inductor does not cause instant current. Instead, the current grows gradually with a time constant of L/R seconds. (L in henries, R in ohms). In this case, because current is growing, the time constant is the time to reach 63% of the final current (which is V/R amps).

REACTANCE, IMPEDANCE, RESONANCE

In an AC circuit we can have resistors, inductors and capacitors. Any circuit that has capacitors connected in series with the other components must be a circuit for AC only, because capacitors do not pass steady current. Any inductors in a DC circuit will act only as resistors, their inductance has no effect once the current has settled down to its final value. For an AC circuit, however, both capacitors and inductors pass current and will have alternating voltages across them. For a capacitor or inductor, the ratio $\tilde{V}/\tilde{I}$ meaning the ratio of signal voltage to signal current, is called the **reactance** of the capacitor or inductor, symbol X, and is measured in ohms. It's measured in ohms because resistance is the ratio of V/I, using DC values that also result in the unit, ohm.

Why use a different name for these 'AC' ohms? Well, for a start, DC doesn't flow through a capacitor at all, and the resistance of an inductor is only the resistance of the wire it's made from. For an encore, there's another big difference. When an alternating current flows through a resistor, there is, of course, an alternating voltage across the resistor. This voltage is exactly in step with the

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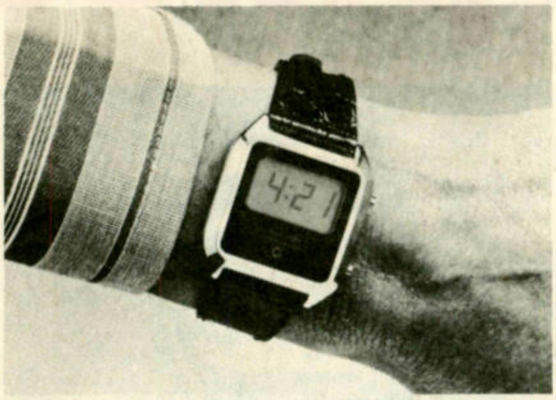

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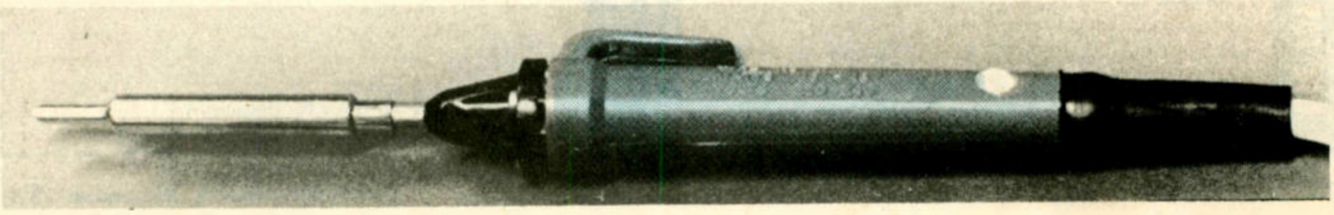

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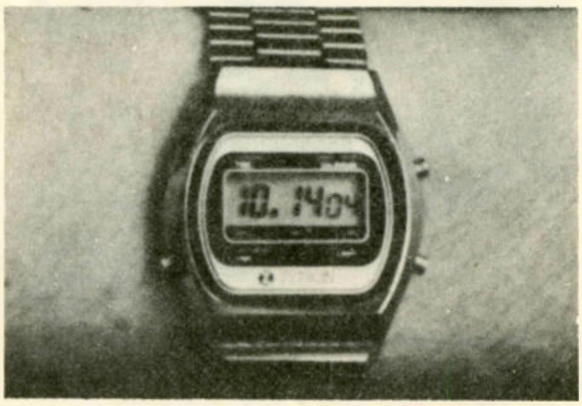

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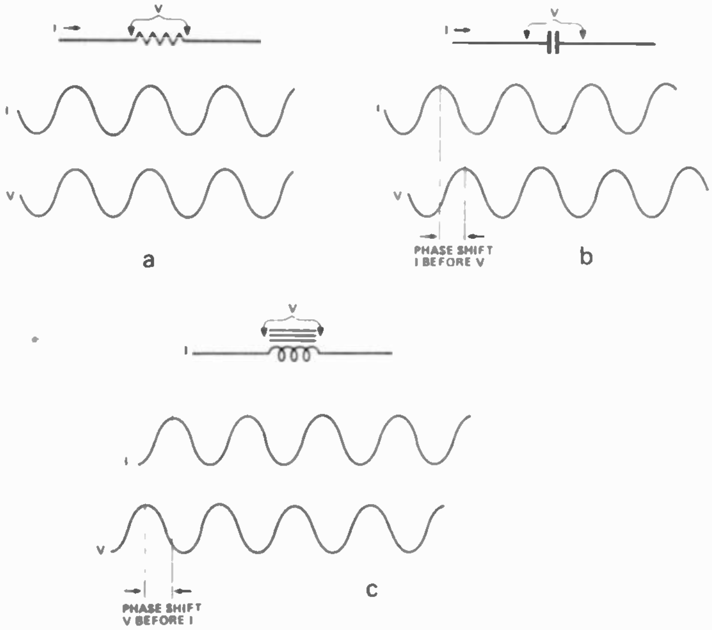


Fig. 9. Phase shift. a) When alternating current passes through a resistor, the waves of voltage and of current are in step. b) When AC is applied to a capacitor, the current wave is a quarter cycle (90°) before the voltage wave. c) When AC passes through an inductor, the current wave is a quarter cycle (90°) after the voltage wave.

current — when the current is zero, the voltage is zero, when the current is at its positive peak, the voltage is at its positive peak, and so on. Reactances don't behave like this. Instead, the voltage wave is shifted compared to the current wave, so that we have maximum voltage when the current is zero and zero voltage when the current is maximum. This effect is called a 90° phase shift. The reason for the 90° label is that the shift is one quarter of a cycle, and an alternator generates one cycle of AC by 360° of rotation, hence a quarter cycle is 90°.

Capacitors cause the voltage peak to be a quarter cycle later than the current peak; inductors cause the current peak to be a quarter cycle later than the voltage peak. One simple way to remember which way round it is is the word **C-I-V-I-L** C (for capacitor), I before V; V before I in L (inductor).

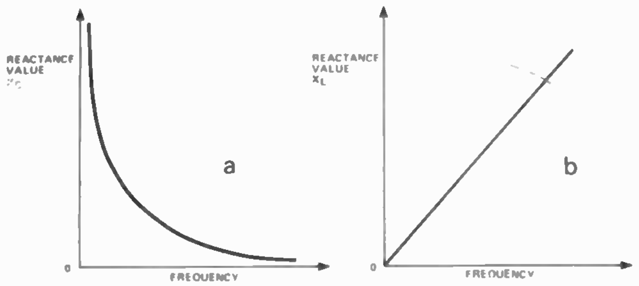


Fig. 10. Reactance is not constant. a) The reactance of a capacitor is very high for low-frequency signals, very low for high frequency signals. b) The reactance of an inductor is very low for low-frequency signals, very high for high-frequency signals.

The most noticable difference between reactance and resistance, though, becomes obvious when we change the frequency of the AC supply. Inductors have more reactance at high frequencies than at low frequencies. Capacitors have less reactance at high frequencies than at low frequencies. Graphs showing reactance size plotted against frequency look as shown in Fig. 10. For an inductor, the size of reactance is given by $X_L = 6.3 \times f \times L$, with f in hertz, L in henries.

For exple, a 0.1 H inductor at a frequency of 400 Hz has a reactance of 252 ohms.

For a capacitor, the size of reactance is given by

$$X_c = \frac{1}{6.3 \times f \times C}$$

Now we have to be careful here. C has to be in units of farads, and we usually use microfarads or smaller units. For example, the reactance of a 0.1uF capacitor at 5 kHz is:

$$X_c = \frac{1}{6.3 \times 5000 \times 0.1 \times 10^{-6}} = 317 \text{ ohms}$$

Because reactance is different in value at each different frequency, we have to calculate the amount of reactance from the fixed values of inductance or capacitance.

When a circuit contains a resistance and a reactance, the whole circuit is neither perfectly resistive nor perfectly reactive, but a mixture of the two is called **impedance,** symbol Z. The simple laws for adding series or parallel components don't apply to reactances because of the phase shift, and the phase shift of an impedance is somewhere between 0° and 90°.

One type of impedance is rather special. When a circuit contains a resistor, a capacitor and an inductor all in series, or all in parallel, it doesn't behave like any other circuit we have met so far. At low frequencies, this circuit behaves like an inductor, at high frequencies, it behaves like a capacitor. At one frequency in between, called the **resonant frequency,** or frequency of resonance, the circuit behaves like a resistance. At this frequency, the reactances of the capacitor and of the inductor have balanced each other out, leaving only resistance. How much resistance?

If the capacitor and inductor are in series, making this a series resonant circuit, then the resistance at the frequency of resonance is very low, just the resistance of the wire in the inductor unless other resistance has been added. If the inductor and the capacitor have been connected in parallel, making a parallel resonant circuit, then the resistance at resonant frequency is very high.

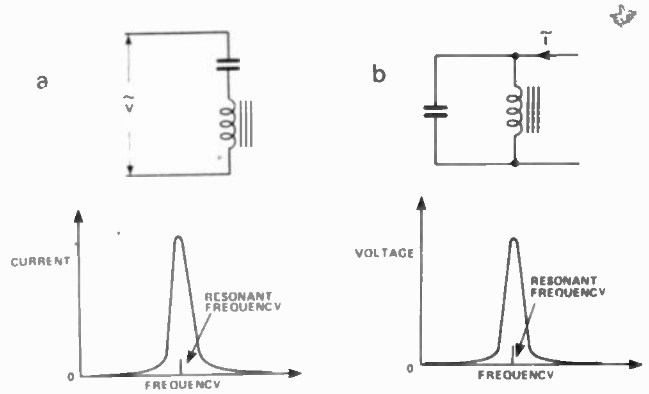


Fig. 11. Resonance. a) Series-resonant circuit; the resistance in the circuit is the resistance of the wire of the inductor. The current is maximum at the resonant frequency, when the circuit has only resistance, no reactance. b) Parallel-resonant circuit. The voltage (and the resistance) is a maximum at the resonant frequency.

unless other resistances have been added in parallel. The effect is shown in Fig. 11. We use resonant circuits for tuning a frequency we want. If a parallel resonant circuit is used as a load, then a signal current will produce a large voltage across the load, but only at and around the frequency of resonance. Radio wave tuning, whether of radio, TV or radar signals depends on this resonance effect which lets us select the frequency we want from all the possible frequencies which can be picked up or generated.

BLOCK DIAGRAMS

A block diagram of an electronic system shows us what is done to a signal, without any detail of how it is done. A block diagram of a car would show an outline of an engine, a gearbox, a clutch and the final drive, but without any details of what happens inside these components. Block diagrams are useful because they show us what to look for in a detailed circuit.

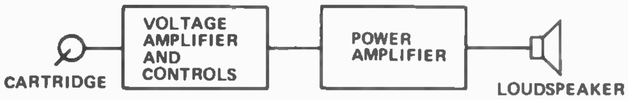


Fig. 12. Block diagram of a record player. The cartridge converts vibration of the stylus into an electrical signal, which is amplified and used to drive the loudspeaker.

For example, Fig. 12 shows a block diagram of a simple record player. The cartridge is the transducer that converts the squiggles on the disc into electrical waves. These are then amplified, the amount of amplification is controlled, and the amplified signal used to drive another transducer, the loudspeaker.

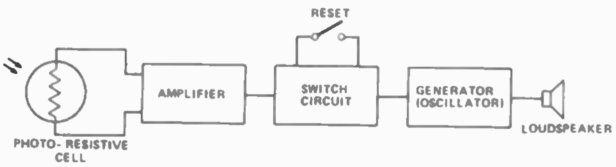


Fig. 13. Block diagram of a light-operated alarm. Light falling on the photocell causes a signal which is amplified and operates the electronic switch. This in turn switches on the oscillator, and so sounds an alarm from the loudspeaker. The alarm sounds until reset by a switch.

Taking another example, Fig. 13 shows an alarm which sounds when a light beam hits a photocell. The light falling on the cell causes a signal which is amplified and used to switch on an audio generator, which in turn causes a sound from a loudspeaker. The actual circuit for this would take much longer to understand. Block diagrams are particularly useful for very complex electronic systems such as TV, radar or computers.

CIRCUIT DIAGRAMS AND SYMBOLS

If we are to be able to build electronics circuits (and that's what we're here for), we need to be able to read and understand circuit diagrams. Why not use photographs and sketches of a finished circuit? Well, it's much more difficult, to start with. Photographs and drawings are useful only if your components look identical to the ones in the photo, and if you want to copy exactly the layout in the photo. If you can read circuit diagrams, you can use any shape of components, and make your circuits as you want them. It's like the difference between building from a kit and rolling your own.

Circuit diagrams use symbols for each component, and some of the most common symbols are shown in Table 1. Notice the way arrows are used. For components like resistors, capacitors and inductors, arrows are used to mean a variable quantity (a variable resistor or potentiometer, variable capacitors, variable inductors) which can be adjusted. A different symbol is used for preset values that are set to some value and then left alone. An arrowhead used with components such as diodes and transistors shows the normal (+ to —) direction of current flow.

A circuit diagram shows what components are connected together, *not* how they are arranged. A circuit may show a line, representing a connection, joining a battery + pole to one end of a resistor. In the practical layout of the circuit, these components might be near each other or several centimetres apart, but they must be joined by wires or metal strips. The great advantage of a circuit diagram is that it shows the action of each component in a circuit, no matter where it happens to be placed physically. Trying to figure out the action of a circuit by looking at its arrangement on a board is nobody's idea of good clean fun!

In many circuit diagrams the symbol for an earth or ground connection is shown and this sometimes puzzles beginners. It's a hangover from the old days of telegraphs. At first, the electric telegraph used two lines connecting transmitter and receiver. The pioneers then found that they could use one wire line, with the return current flowing through the earth itself, and to do this, the return was taken to a large metal plate buried in the ground. From then on, its been earth in the U.K. and ground in the U.S.A. and ever shall be.

Nowadays, mains operated circuits use an earth connection for safety, so that any mains voltage fault will cause a large current through the earth connection (rather than through you) so blowing the fuses.

In battery powered equipment, the earth or ground connection may simply be to any metalwork, such as a case. This ensures that the case is at the same voltage as the signal zero voltage line, usually battery negative. The purpose of this is to make sure that the metalwork does not cause interference by radiating signals into or out of the circuit. For many circuits an earth connection is not needed at all, but the earth symbol is sometimes still used on circuit diagrams to show which line of connections is at zero signal voltage.

PRACTICAL CIRCUIT CONSTRUCTION

Laying out a circuit from a circuit diagram is one of the most satisfying parts of electronics, and yet is seldom taught. In the old days of valves, laying out a circuit used to be a metal bashing exercise which had the constructor pretty cheesed off with the circuit before any wires had been soldered, but modern components and circuit boards have made the whole process so much easier.

Start by looking at the circuit and finding the circuit junctions. A circuit junction is where wires from various

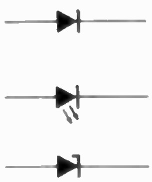
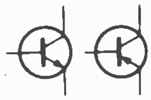
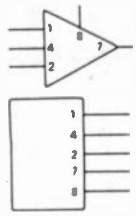
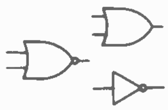
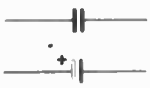
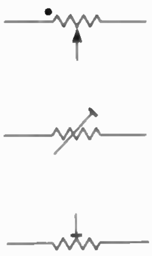
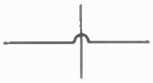
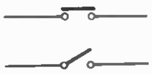
	Three types of diode. The first is just a diode, the second is a light emitting diode (which glows when current passes through it). The third is a zener diode, used for creating fixed voltages.
	Two types of transistor. The first is NPN, the second PNP.
	Integrated circuits. The box can be of almost any shape, although the top one is usually used to indicate some form of amplifier. The numbers refer to the pin numbers on the IC package.
	Logic gates. Logic ICs usually contain several of these each, and so they are suffixed IC1a, IC14b, et cetera.
	A resistor.
	Two types of capacitor. The lower one is of the "elec-trolytic" or "tantalum" type and can only be used one way round.
	A coil. The lines indicate what it was wound on. Two coils which share the same lines represent a transformer.
	Various forms of variable resistor. The top one is panel mounting, the dot representing the right-hand side when viewed from the front. The other two are pre-set resistors which are used for setting up only. The middle one has its sliding contact connected to one end of the resistive "track."
	A variable capacitor.
	Two wires crossing on a diagram without touching.
	Earth symbol. Usually means battery negative terminal or chassis.
	Two different types of switch. The upper one is only closed while it is held closed.
	A loudspeaker.
	A fuse.
	A battery. The short terminal is negative (easy to remember it looks like a "—").
	A "jack" socket and a "phono" socket.

Table 1. Commonly-used circuit symbols.

components are all joined together. For example, Fig. 14 shows a piece of circuit with five junction points. At 1 the battery connects to R1. At junction 2 the input signal (from a socket) connects to C1. At 3, components C1, R1, R2, R3 are all connected together and at 4 the output socket joins to R3 and C2. 5 is the junction at which battery negative connects to C2 and R2. Each of the components in this circuit has two leads, and these two leads must be taken to different junctions. Later we shall be using components with three leads (such as transistors) but the same rules apply, the three different leads on each component must go to three different junctions.

Why should we disfigure our circuit diagrams with these pencilled loops? Well, the reason is that it makes circuit construction simple, electronics by numbers! Practically all circuits nowadays are built on insulating boards which have copper strips laid on them. Each of these copper strips can be used as a junction, with the wire leads of components soldered to the strips. Some types of boards use perforated copper strips, with component lead-out wires fed from the plain side through the holes to the copper side and soldered. Another type of board uses plain undrilled, ready-soldered strips, and the component lead-out wires are soldered directly in place. Whatever type is used one strip represents one circuit junction (the strip can of course be broken to form two or more).

Using our example again we take a circuit board, and make strips with numbers, 1,2,3,4,5. All we need to do now is to connect the leads of each component across the strips shown in the circuit diagram. For example, R1 is connected between strip 1 and strip 3, R2 is connected between strip 3 and strip 5, C2 is connected between strip 4 and strip 5 and so on. One type of board even has the strips already numbered for you! Couldn't be easier! The only thing to watch is that if you use the drilled type of copper strip board, you must have the strips numbered on *each* side. The reason is that a line of holes looks pretty much the same as any other line of holes, and it's easy to mistake one for another if they are unmarked. The undrilled type of board is already numbered and needs no other preparation.

Mastered soldering? Make sure the bit of the iron (electric 25W or less) is clean, then switch on and allow it to warm up. Place the component so that its lead is at the correct part of the track of the board. Hold the iron so that its tip touches both track and component leadout wire. Now touch this hot zone with the end of a piece of resin-cored solder and watch the solder run around the wire and onto the track. When it's smooth and before it stops smoking, take the iron away. Let it all cool before disturbing it. That's all! **Do** clean the wire and the track, keep the iron hot and clean. **Don't** snatch the iron away before the solder has flowed freely or keep it on so long that the board starts to burn. **HE**

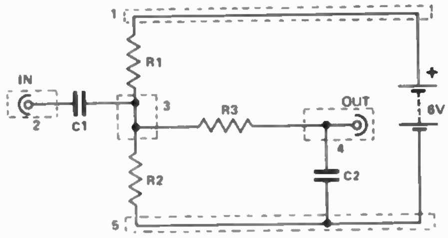


Fig. 14. Circuit junctions. Marking out a simple circuit diagram so that it can be easily built on strip-board.

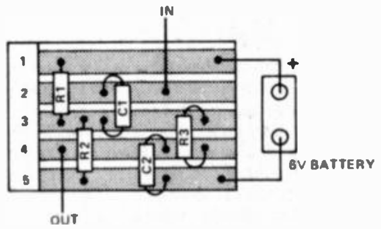


Fig. 15. Piece of strip-board with the circuit of Fig. 14. assembled.

Understanding Bias

Tape recorder bias is a much misunderstood subject. Ron Harris shares his unbiased views . . .

MOST USERS of tape machines, be they cassette, Elcaset or open-reel devotees are aware of the presence of the bias oscillator within their machine. In recent times they can also hardly have missed the trend to allow users to alter the bias setting for different types of tape coating.

Many more advanced cassette recorders sport switches which allow for three settings: low noise, chrome and ferrichrome. It may seem strange to have an electrical switch marked up for different materials, and it is all too common for people simply to leave that switch in the position it happened to emerge from the packing case in, and to use whatever tape comes to hand — either from the back of a passing lorry or from 'Shifty Sid's Super Discount Emporium'.

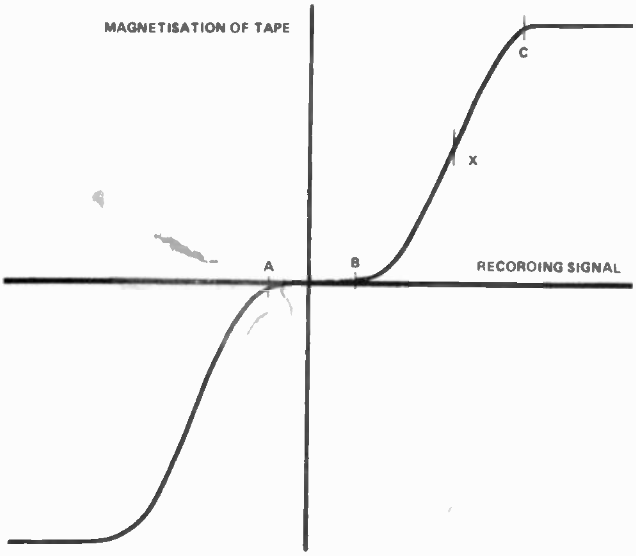


Fig 1: Graph of tape magnetisation produced against magnetising signal flowing in the tape head. This clearly illustrates the great problem associated with tape recording — the fact that the effect is not a linear one. The section in the centre of the curve between A and B shows that over a range of small signal values, no magnetism at all is imparted to the tape. Beyond C on the curve, 'saturation' occurs — no further increase is possible regardless of changes in the signal.

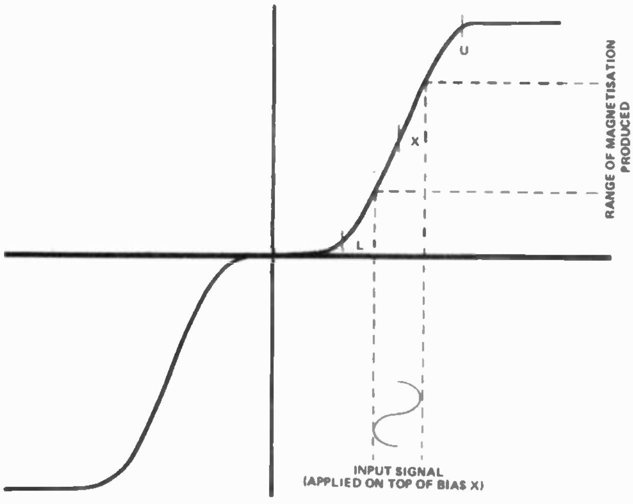


Fig 2: DC bias. This involves adding a steady voltage to the input signal and recording them both together. As the diagram shows this effectively shifts the signal onto the useful linear section of the curve. L and U are the limits of operation for non-distorted output. Beyond these points the curve is not a straight line, and the transfer of signal to tape is a non-linear one.

A criminal waste of potential performance, this. Tape bias is there to help the machine overcome the greatest drawback of magnetic tape as a recording medium — non-linearity.

HEADING FOR TROUBLE

Let's start by considering what happens as the tape passes the recording head, without any thought of bias. If the signal in the record head is very small, no magnetisation at all will occur on the tape.

On the graph of figure 1, any amount of signal between A and B will produce the same effect on the tape — zero. At values of signal greater than B, the tape will retain some magnetism as it moves away — it has been recorded upon. However, if we go on increasing our value of signal up to point C, the tape refuses to accept any more magnetisation — saturates — and different values of current will now leave the same amount of magnetisation on the tape.

All this means that only between points B and C can we hope to record a varying signal — speech, etc — on the tape: i.e., make the amount of magnetism on it follow the signal flowing in the recording head. Between these points the response is almost a straight line (ie, linear).

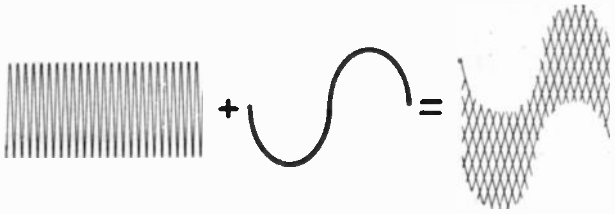


Fig 3: Addition of the high frequency AC bias signal with the lower frequency signal. The total is used to perform the magnetisation of the tape. For best reproduction the bias frequency should be at least four times the highest frequency to be recorded as a signal. Cassette machines use around 90kHz usually.

AC OR DC — WHO'S BIAS?

One way around this would be to never let the current in the head fall to zero, so that the portion of the graph between A and B is never used. This means putting a current through it constantly to make the lowest value, say, X on the graph. Doing this is called *biassing.*

An incoming signal would then be added to the constant flow, so that the signal varies about the value X. The disadvantages of this are that the signal is limited to values which produce magnetisation between values L and U on figure 2. This steady DC current — bias current — also raises the amount of noise heard on replay of the tape. This is due to the fact that the bias current does not have an equal effect on all the magnetic particles upon the tape. The differences between the effects will appear as a 'noise' signal.

DC bias is nowadays used only on some low-priced cassette recorders, because of its inherent disadvantages of low signal-to-noise ratio and limited range of signal.

AC bias can overcome these disadvantages of DC bias, and allows a much wider range of signal onto the tape. A high frequency signal is used for the job, and it should be at least four times higher than the highest frequency to be recorded, to make sure it does not interfere with the signal we want to record.

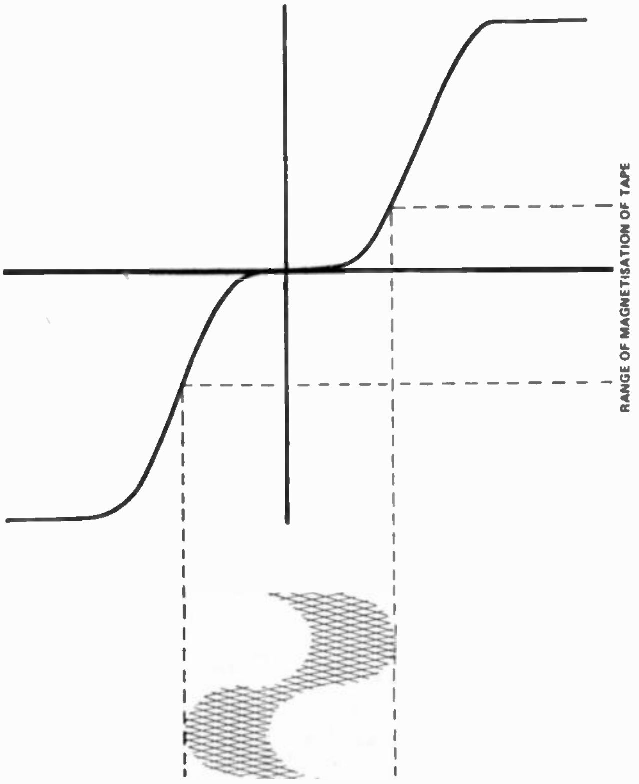


Fig 4: Recording with AC bias. Since the bias signal used is AC it can affectively 'fill in' the flat portion of the curve, allowing the signal to make use of both linear parts of the curve and doubling the range of magnetisation possible with DC bias.

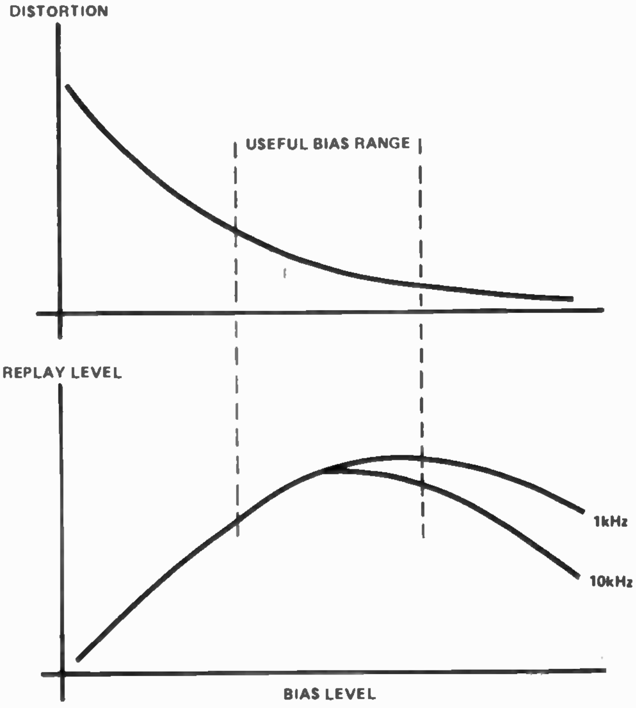


Fig 5: The effect of amount of bias on both distortion and high frequency response. These graphs are the reason switching is needed on tape machines. For best compromise performance the machine should operate in the centre of the useful bias range. The amount of bias signal required to achieve this will vary from tape to tape — producing whole sets of these curves up and down the graph — and bias level has to be adjusted to correctly position the operation.

This signal is generated by the bias oscillator within the recorder and is generally around 100kHz in modern machines. This constant value high frequency signal is added to the signal and both are recorded on the tape. The bias current 'fills in' the flat portion of the graph so that the total current in the recording head never falls to zero.

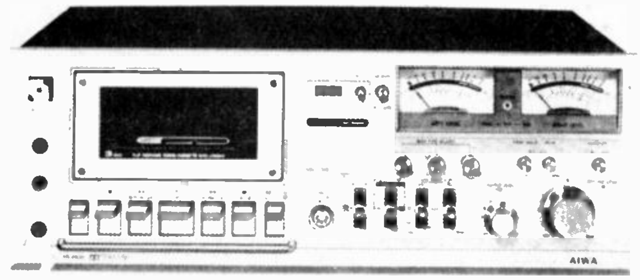
Since the bias is AC the current takes the tape into magnetisation on both sides of the axis, and so an added signal can utilise both sides of the graph such that the peak-to-peak values can be twice the DC value which induces saturation in the tape. Noise is also much less because the bias signal is so weak.

RESPONSE-IBLE DECISION

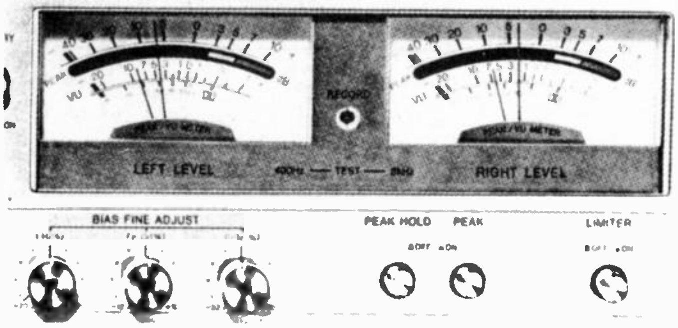
Since the frequency of the bias signal is so much higher than the audible spectrum, there is no chance of it being picked up by the heads — witness the fact that Nakimichi machines are famed for their ability to replay 20kHz, never mind 90kHz!

This same bias signal, greatly increased in level, can be also used to clean (erase) the tape — an added bonus.

Bias, then, reduces distortion as it is increased. However, there comes a point where the high frequency response begins to suffer (see Fig. 5). So optimising the bias means applying the maximum amount that will not degrade response.



The Aiwa AD68DO cassette machine. Along with its younger brother the 6900, this machine offers the best compromise of bias performance. As well as the usual switches, fine tuning controls are incorporated which allow the user to peak-up performance for any tape.



Sonys excellent EL7 recorder. Conceived as a cassette tape machine which would have open-reel performance (by using tape at a higher speed basically) even if it is dependent upon those bias switches to optimise performance.

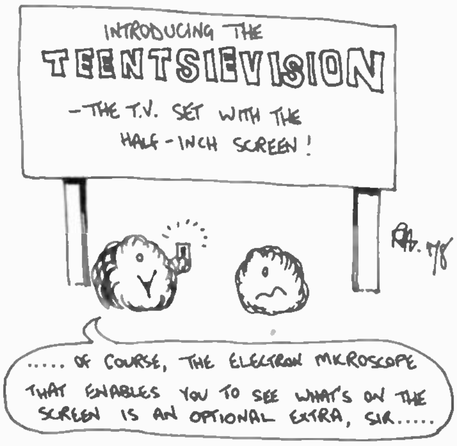
This maximum will vary from tape type to tape type, and should ideally be set up for each brand of recording tape. Herein lies the reason for those switches. Each tape type therefore can be (nearly) optimised by changing the switches over. Some machines are now carrying this trend a stage further. For instance, the Aiwa AD 6800 allows the bias to be altered by the user to optimise the high frequency response by 'fine tuning' in addition to the simple switching usually provided.

SUMMARY

Bias is thus an alternating current signal of high frequency which is added to the audio signal to be recorded. Both are recorded together. This overcomes the non-linearity of the magnetic properties of tape, thus allowing a higher value of signal to be recorded without distortion and aiding signal-to-noise ratio.

To make the best use of your tape machine, set the bias switching to the position marked for the type of tape you intend to use. If you do not, high frequency response and noise may well suffer.

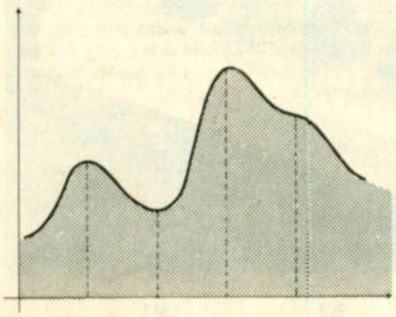
HE



Hobby Electronics

Next Month

4-Channel Equaliser

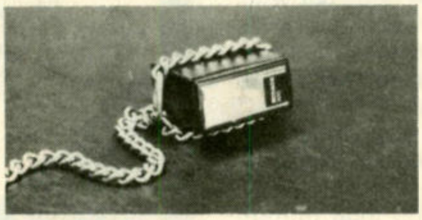


A fully-fledged graphic equaliser with four bands, allowing you to adjust the response of your Hi-Fi to suit the room it's in! Alternatively, this unit can be used as a really sophisticated tone control. This project was designed by a professional audio consultant especially for HE. We think it'll be a winner!

Viewdata

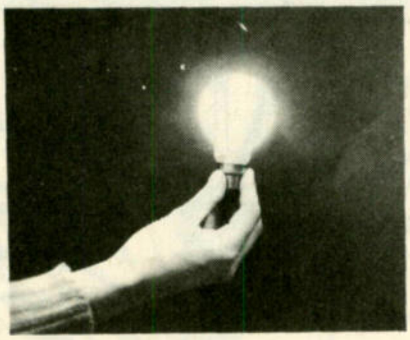
One of the most exciting developments in modern TV technology is the advent of data transmission and display. Viewdata is Britain's answer to advances which could mean shopping from the home, a computer terminal in every room or even the abolition of commuting!

Slave Flash



Using one flash gun is fairly straightforward — but how do you use two or more simultaneously?

Touch Switch

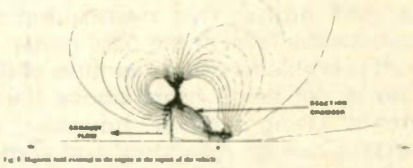


A switch with no moving parts! Just touch it and turn on the lights, motors or whatever turns you on. By the way, the above photo is not an illustration of the switch in action, but one of our staff having a bright idea.

Holograms

Following on from the LASER article in this issue, we look into (!) holograms — what are they, how are they made and what use are they. This is a fascinating topic and one which is sure to make a big impact on all our lives in the future.

Project Daedalus

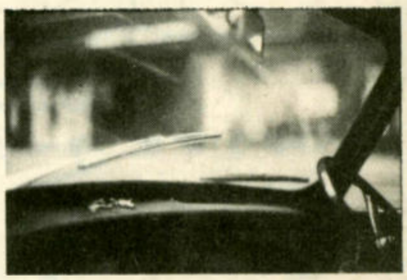


The British Interplanetary Society has just published a report which shows that interstellar flight by an un-manned vehicle is possible with modern technology. The report is nearly 200 pages of detailed drawings, calculations and specifications. We examine it clearly in detail.

BASIC Programming

If you've ever wondered exactly what's involved in programming a computer, then this is for you. We look at BASIC — one of the most popular computer languages — and see what it's all about. This article will require no previous knowledge and will be much more than an introduction to the subject.

Variwiper



Ever been driving in one of those horrible drizzles which is too fine for the wipers to work properly? This circuit makes them repeat one sweep at pre-set time intervals — ideal for those conditions.

January issue will be on sale on December 8th

The items mentioned here are those planned for the next issue but circumstances may affect the actual content

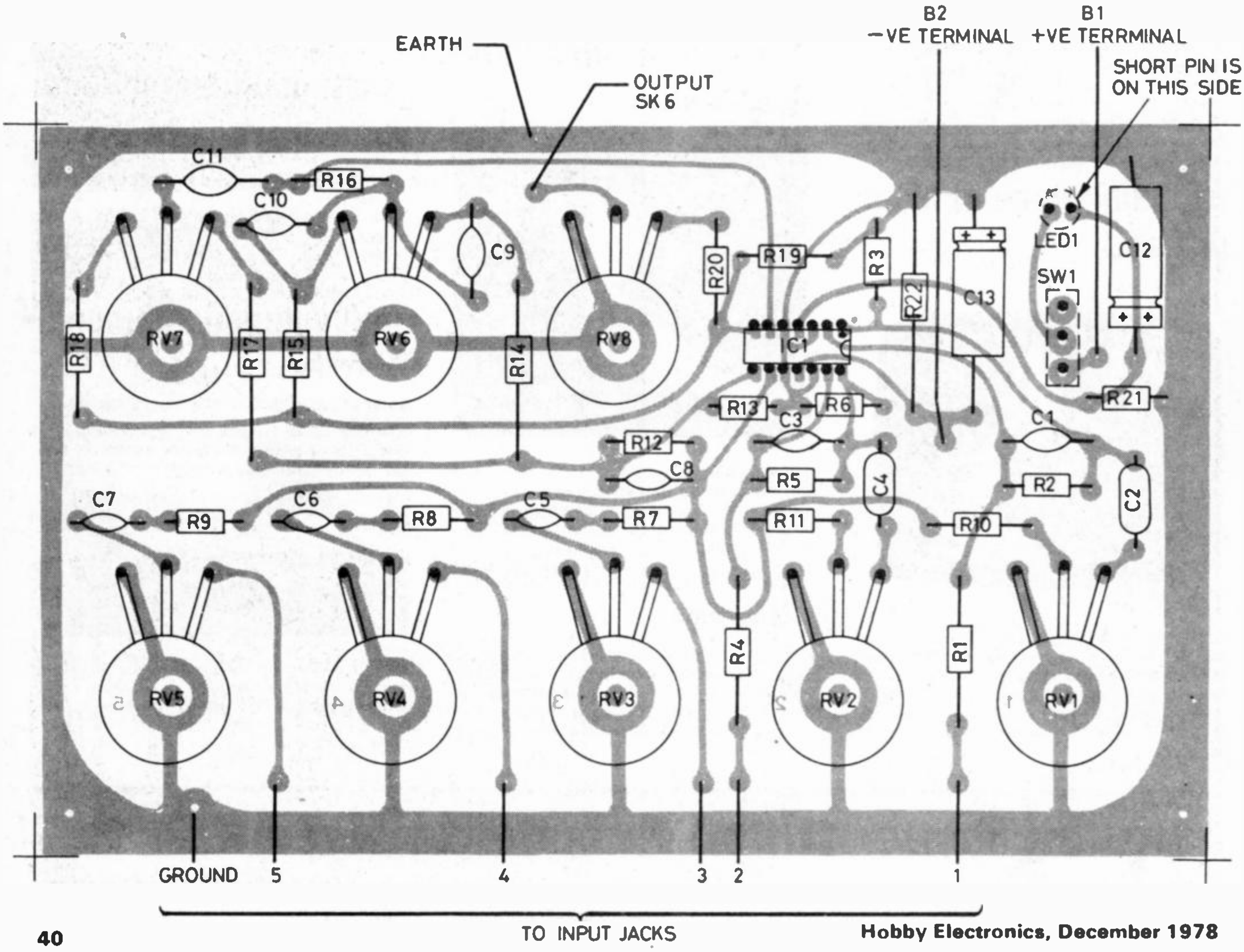
Audio Mixer

This project should prove invaluable to anyone who is into live music. That is, unless they've just spent five times as much on a commercial one!

AT FIRST GLANCE this may not seem all that useful an addition to a small band's equipment. It consists basically of input circuitry for handling up to five microphones, guitars or whatever. All it does to these is to mix them together, provide some tone control and send them back out of a single output.

Most small bands which do not own a mixer handle the problem of sound mix by using a PA amplifier with several inputs. This means that the bass guitarist controls the level of the bass guitar, et cetera. This can lead to problems when members of the band decide that they're not being heard above the rest of the instruments! Using a mixer, however, the overall sound balance can be monitored and controlled by someone sitting in the audience.

This mixer also gives control over the total output level. This means that the band can be faded in or out at the start and finish of a number.



Apart from the facilities offered, what differentiates a good mixer from a mediocre one is the level of 'noise'. This is the amount of 'hiss' you hear with everything turned to full volume and no input. The noise level in this design compares very favourably with commercial mixers in a much higher price range.

Being battery-driven, this unit is particularly suited to 'on the road' applications, but other possible uses include stage sound effects cueing, tape recording, electronic music synthesis, et cetera.

CONSTRUCTION — THE BOARD

The important thing to watch is the orientation of C12, C13 and IC1. If you follow the 'overlay' carefully you shouldn't have any trouble. Another thing to be wary of if you are using an IC socket for IC1 (an IC socket is usually soldered onto the board — the IC then plugs into it to save the risk of heat damage during soldering), then be careful that none of the IC pins are bent under the body of the IC.

The LED will only work one way round — one lead will be longer than the other see the overlay to find out which one.

SW1 is not designed for printed circuit board (PCB) mounting and so the holes for it will be large. The potentiometer spindles will have to cut to length — the final length depending on what type of knobs you buy. Don't cut them until you've constructed the rest of the project. The potentiometer leads will have to be 'lengthened' by soldering stiff wires onto them so that they will reach the board.

Parts List

RESISTORS (all ¼W, 5% tolerance)	
R1, 4	10k
R2, 5	100k
R3, 6, 13, 19	4k7
R7, 8, 9, 10, 11	56k
R12	100k
R14, 15, 16	10k
R17, 18	3k9
R20	1k0
R21, 22	4k7

CAPACITORS		
C1, 3	56p	polyester
C2, 4	220n	polyester
C5, 6, 7	100n	polyester
C8	56p	polyester
C9, 10	47n	polyester
C11	4n7	polyester
C12, 13	220u	16V electrolytic

POTENTIOMETERS		
RV1, 2, 3, 4, 5	25k	logarithmic
RV6	100k	linear
RV7	500k	linear
RV8	5k	logarithmic

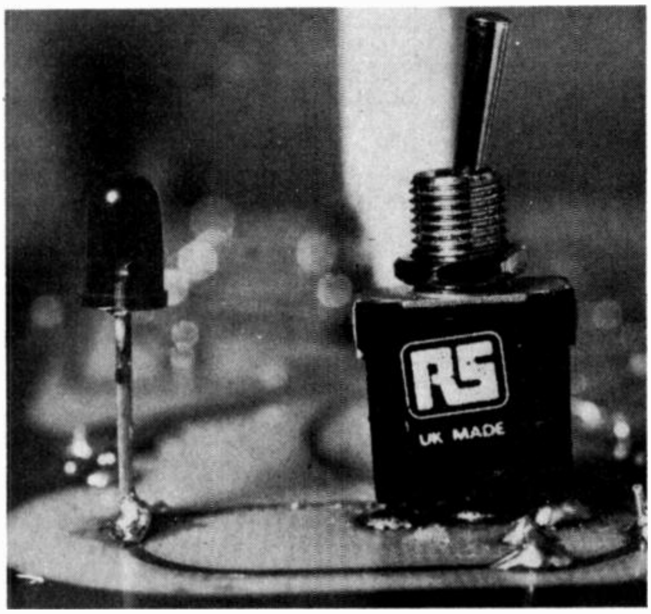
SEMICONDUCTORS	
IC1	LM324
LED1	any red LED

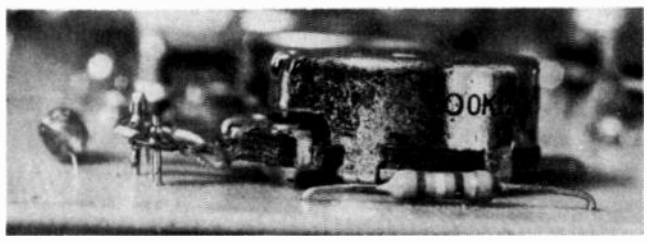
MISCELLANEOUS

Printed circuit board, single-pole double-throw switch, 2 off PP3 9V battery (or similar), battery clips to suit, 14-pin integrated circuit socket, VERO sloping-front case, knobs, 6 mono shorting jack sockets.

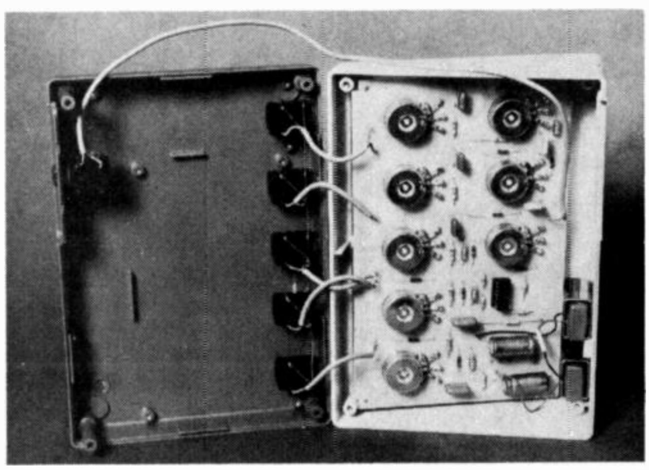
Approximate Cost: £15

The case for this project is from the VERO range of cases. It should be available from most mail order firms and the same goes for the other components. The switch is an RS single pole, double throw type — any other type may not fit the PCB.



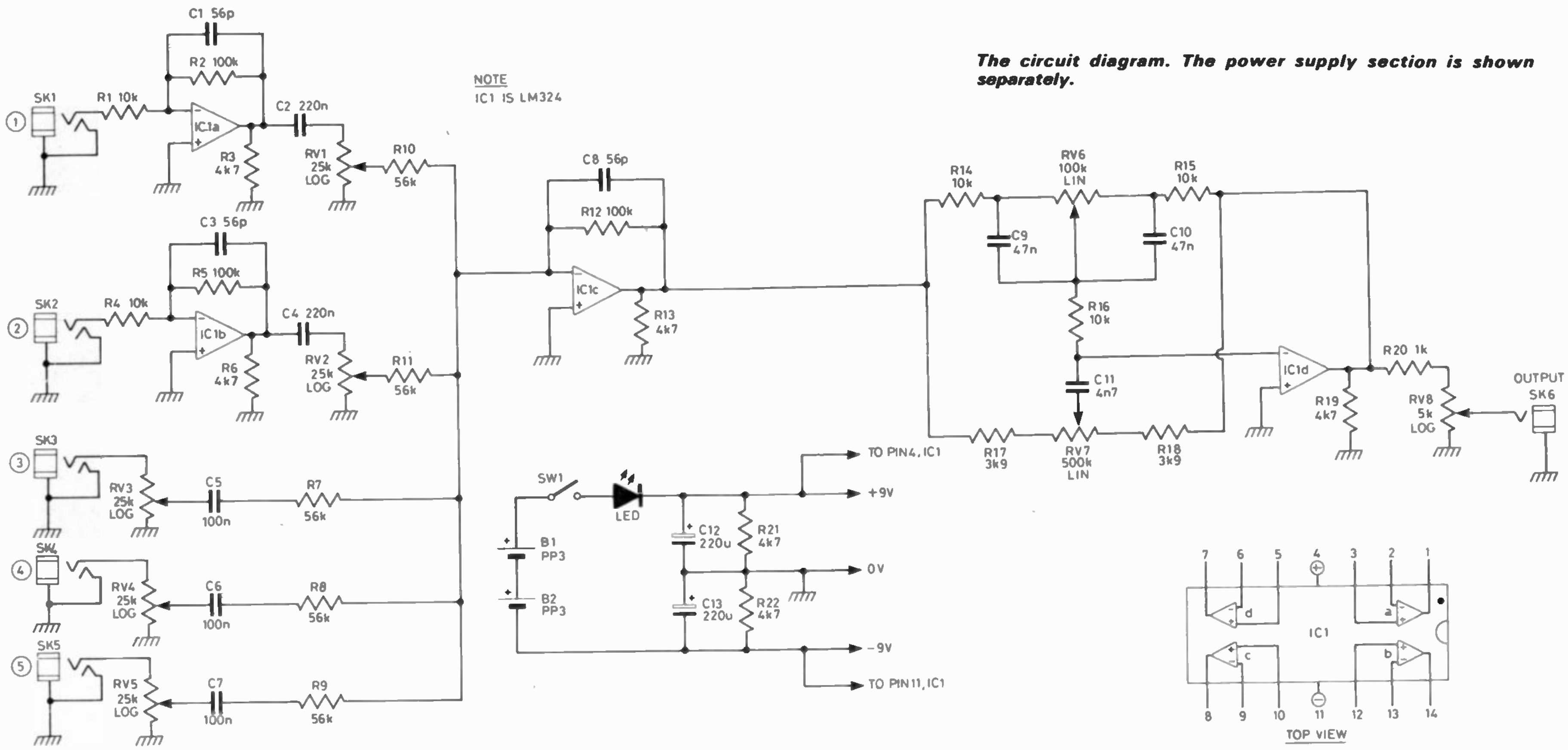


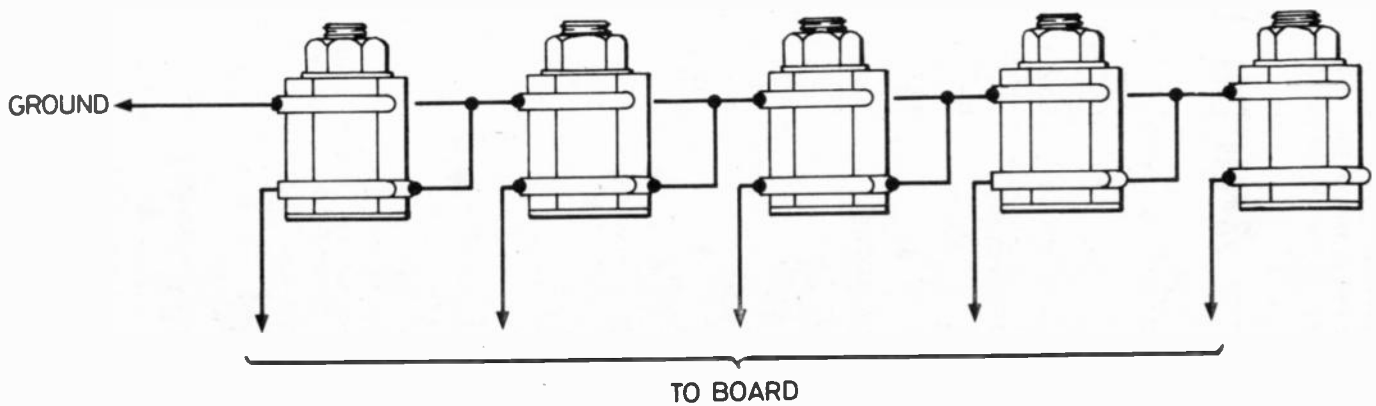
These shots show how the LED, switch and potentiometers are soldered into place. Do not solder the pots until you have bolted them in or you will risk straining the soldered joints.



An internal view. Note the wiring layout.

The circuit diagram. The power supply section is shown separately.

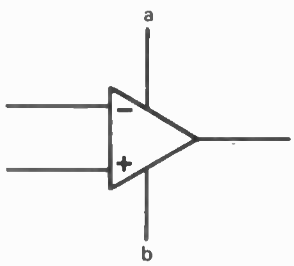




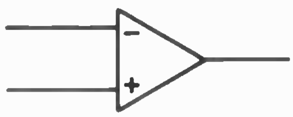
Pinout diagram for IC1. The LM324 IC contains four operational amplifiers with common power supply inputs.

How it Works

An operational amplifier is shown like this:



Connections a and b are the power supply leads. These are sometimes (as here) omitted for clarity. This leaves:

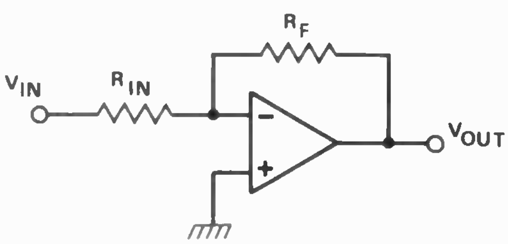


The leads at the left are inputs and the one at the right is the output. The "—" input is called the inverting input and the "+" input is called — in a burst of ingenuity, no doubt — the non-inverting input.

The operational amplifier is a very simple device in its operation, although each may contain (in a sub-miniature form) dozens of transistors, capacitors, etc.

All it does is to subtract the "—" input voltage from the "+" input voltage, multiply the result by a very large number (called the 'open-loop gain' for reasons which we won't go into at this stage) and output the result. That's all it does, and yet it's one of the most flexible active components in use.

Suppose we connect it like this:



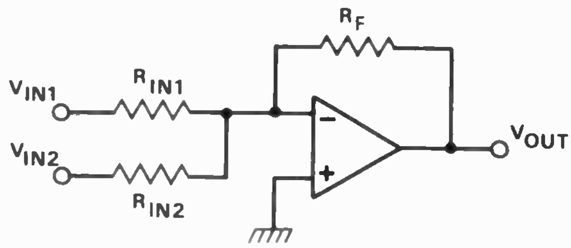
Since the non-inverting input is 'earthed', the voltage on it must be zero. Let's suppose for the moment that the inverting input is above zero — the output will go below zero. In fact, it will go a lot below zero (remember, the open loop gain is a very large number, typically 20 000. This will cause the inverting input to be 'dragged' down' (due to the current through R_F—the 'feedback' resistor). Eventually, the whole thing will settle down with the inverting input at zero volts.

Now, if we put current into the inverting input through the input resistor, the op-amp (operational amplifier) will change the output voltage until the whole thing balances again. The current through the feedback resistor will always be the same as the current through the input resistor and the inverting input will stay at zero volts.

The output voltage will always be a negative number times the input voltage:

$$V_{OUT} = -G x V_{IN}$$

The value of G will be R_F/R_{IN}
If we then add a second input:



The voltage at the inverting input will stay at zero — the circuit will operate exactly as before, except that the output will be $V_{OUT} = (G_1 \times V_{IN1}) + (G_2 \times V_{IN2})$. In other words, the output voltage will be the sum of the amplified input voltages. Using this circuit, we can 'mix' signals together to form a composite output.

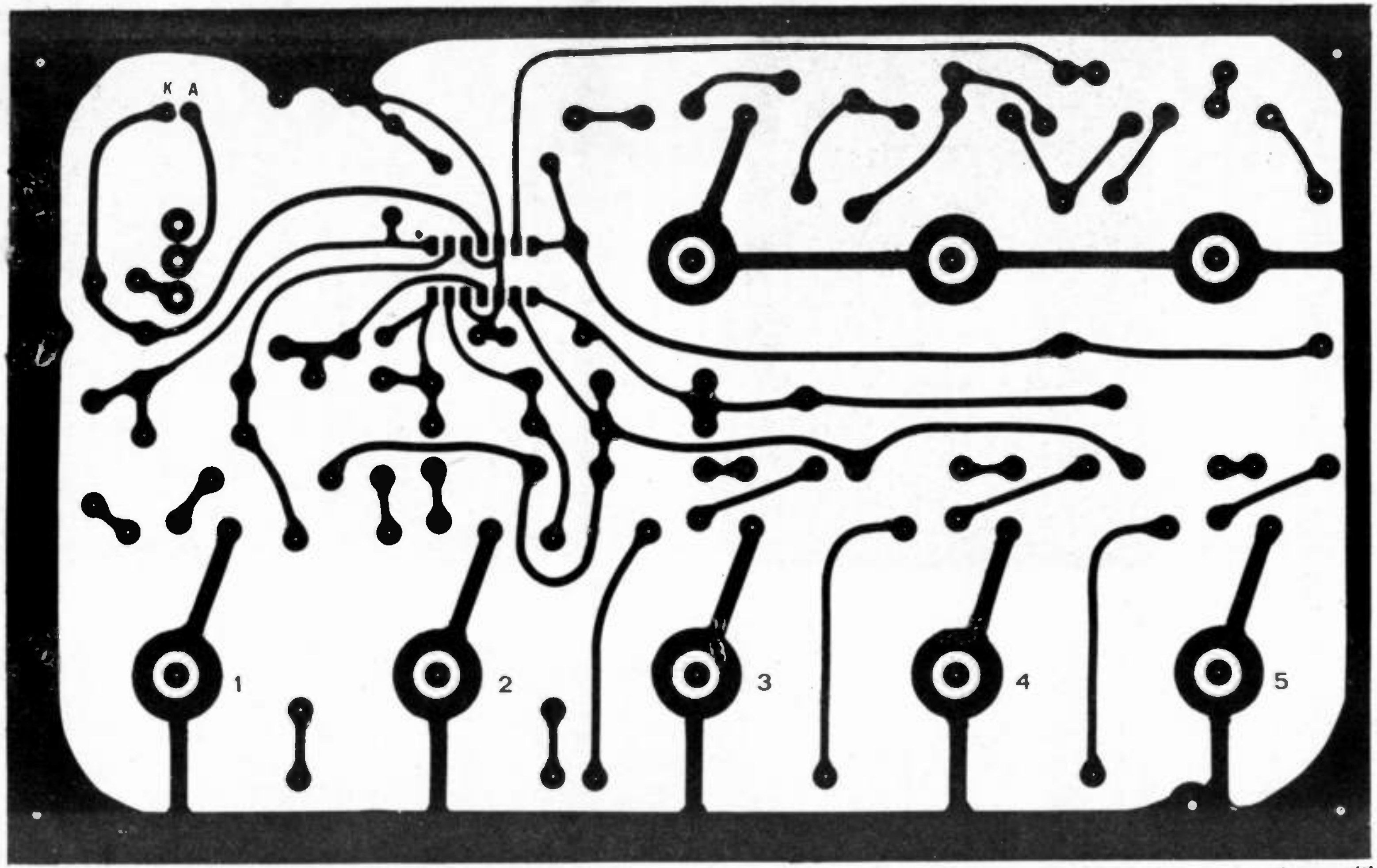
This form of circuit is called a 'virtual earth mixer' because the inverting input remains at zero volts (ie earth voltage). Any number of inputs may be mixed in this way by adding more input resistors.

Looking at the circuit diagram, it's pretty obvious what's happening (although there are some 'fiddley bits' which will require explanation).

IC1a and IC1b are used to boost the low-level inputs from SK1 and SK2. The gain, G, of each will be 100k/10k = 10 times. C1 and C3 are required for the stability of the operational amplifier and R3 and R6 are 'pull-down' resistors. These are required because this particular device is good at supplying current but useless at shorting it to earth. These resistors help.

The outputs are AC coupled (to remove any DC bias which may be present) by C2 and C's 4 thru 7. The inputs to SK3, 4 and 5 should be of a high enough level that they don't require any extra amplification. Resistors 9 thru 12 and IC1c form the virtual earth mixer itself. Again, C8 and R13 are there to help the device along. IC1d and associated components form a standard 'Baxendall' tone control circuit which we won't go into here.

The power supply to the IC is through LED1. This means that the effective supply voltage is 9+9—2=16 volts (the voltage drop across a LED is about two volts), but this is sufficient.



The foil pattern. Printed circuit boards can either be made at home (see PCB feature in this issue) or bought from advertisers.

CONSTRUCTION — THE REST

The PCB should have holes which match threads on the case but don't screw it down until you've soldered the wires on!

Follow the diagram when it comes to wiring up the sockets and you should have no trouble — but use screened cable or you will run into problems due to 'hum' pickup.

The batteries are connected in series — the negative terminal of one connected to the positive terminal of the other. The other two terminals are connected to the board. Use battery clips — they're useful when changing batteries!

USING IT

Inputs 1 and 2 are 'low-level', suitable for microphones, guitars, etc. The other three inputs are for electric piano, synthesiser and the like. A good rule of thumb is that if what you're plugging in has either a) a mains plug or b) a battery, then it can go into one of the high-level inputs (3 to 5). The HE Waa-Waa falls into this category.

Don't leave leads plugged into the unit when there's no input from them — such as guitar leads with no guitars on the end of them. The sockets connect each input to earth if there's no plug inserted as this reduced the amount of 'hum' present.

The tone controls both have a 'neutral' position with the spindle rotated to half way between the end stops.

It is usual to leave the master volume control at full except when fading in or out. This means that the full travel of the control can be utilised, giving a smooth fade. HE

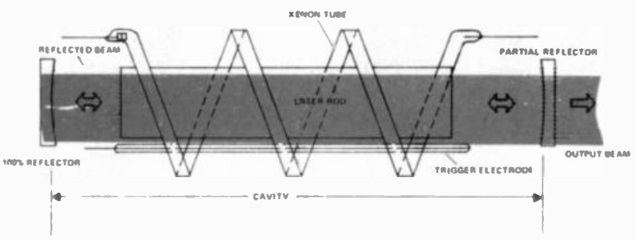
Lasers

Lasers are becoming part of our everyday work and leisure. Jim Perry reviews the state of the art.

THE FIRST LASER was built by a research scientist called Theodore Maiman, while working for the Hughes Aircraft Corporation, in 1960. At the time the laser was called "The ideal solution to yet unfound problems." The problems have been found by the score in the last 18 years!

The word laser is short for Light Amplification by Stimulated Emmission of Radiation, in fact laser devices are oscillators — but who would develop a laser? Radiation from a laser is monochromatic, that is, it occurs as a specific frequency and therefore is a pure source of light. This characteristic enables laser light to be detected in the presence of considerable levels of other optical noise (ie light), with little more than a good optical filter.

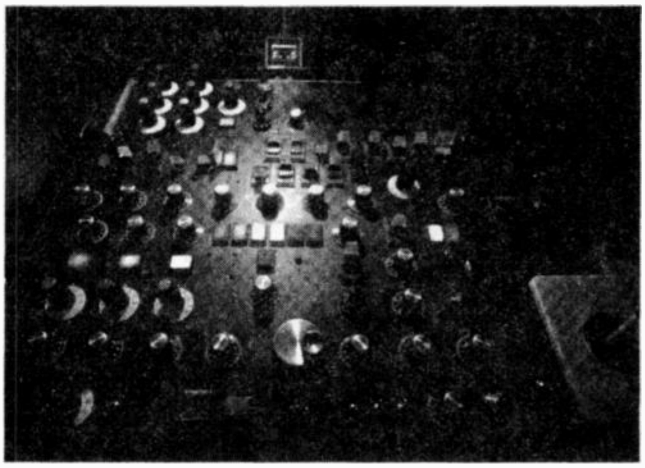
Laser light is also coherent. This means that the majority of the waves in the beam are in phase, giving the light the ability to be used to produce interference patterns. Laser light also emerges as a collimated ray, not as a point source radiating in all directions, and only diverges by typically one part in a million. Without modification the beam can act as a weightless line in space, enabling a whole host of alignment measurements to be made. Because the light is gathered into a small aperture, it is of extreme intensity. With further focussing laser beams can be used to produce points of energy capable of reaching millions of degrees in temperature.



In the ruby laser, as first developed by Theodore Maiman, pump light from a Xenon lamp raised the energy level of chromium atoms in a ruby rod until a pulse of coherent red light emerges from the partial reflector.

USE OF LASERS

Possibly the most publicised use is in laser light shows, such as Laserium and Laserock. These two shows are packing audiences into planetariums all over the world. Because of the very pure nature, and power, of laser light it has an almost indescribeable 'look' about it — a light so pure is never found in nature. When lasers were only seven years old people started experimenting with the artistic effects made possible, by projecting the beam through cut glass and smoke. Modern laser light shows are extremely sophisticated, using powerful Krypton lasers and thousands of pounds worth of electronics, with dozens of scanners. Scanners are mirrors mounted on galvanometers, signals from the electronics are fed into the coils of the galvanometers — and the laser beam deflected by the mirror. It may sound simple, but the special scanners used cost at least £400! With two scanners at right angles, full X-Y movement of the laser beam is possible — and with upwards of 24 scanners shows like laserium need to be seen, to be believed.

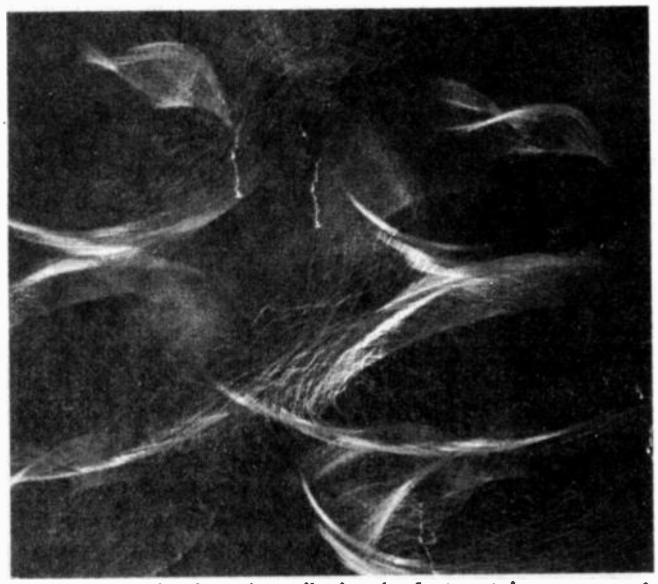


The control panel at Laserium.

MEASUREMENTS

Surveyors (and the Military) use lasers in various ways to measure distance (range). A modulated beam of laser light is transmitted out to a possible target, then it is reflected back to the main unit. Knowing the velocity of light (which we do to about one part in a million in air), the distance travelled is easily calculated from the time taken for the laser beam to return. The main design problem is that of 'marking' the beam in some way, so that the returning beam can be detected. This is usually done either by sending out a single pulse, and waiting for its return — or by transmitting a continuously modulated beam, and comparing the phase difference between signals.

Because the times involved are so small, the laser range finding devices are normally only used for quite large distances (hence giving a longer time), and resolution can be within a few centimeters over several kilometres.



An example of a Laserium display (unfortunately we cannot reproduce the vivid colour which is a major characteristic of such displays).

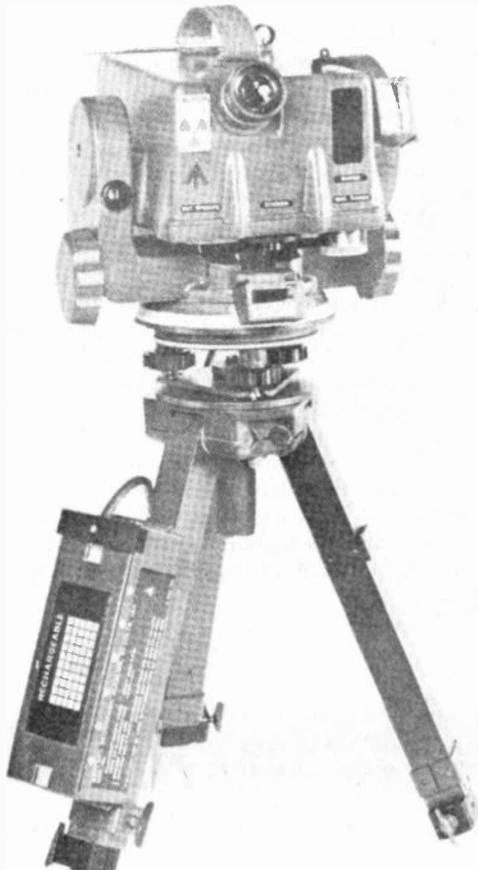
A development of the range finding use is in measuring the profile of land, from a moving plane. If a laser beam is bounced off the ground from a plane in level flight, a readout of the ground profile is possible. When this technique was first used the researchers were puzzled by some obviously wrong results, when flying over lakes. It turned out that the laser beam can even travel through water, and return (at a rather lower intensity) to the aircraft — they were getting a profile of the lake bottom! Further research has now been started into laser depth finders.

LASER WEAPONS

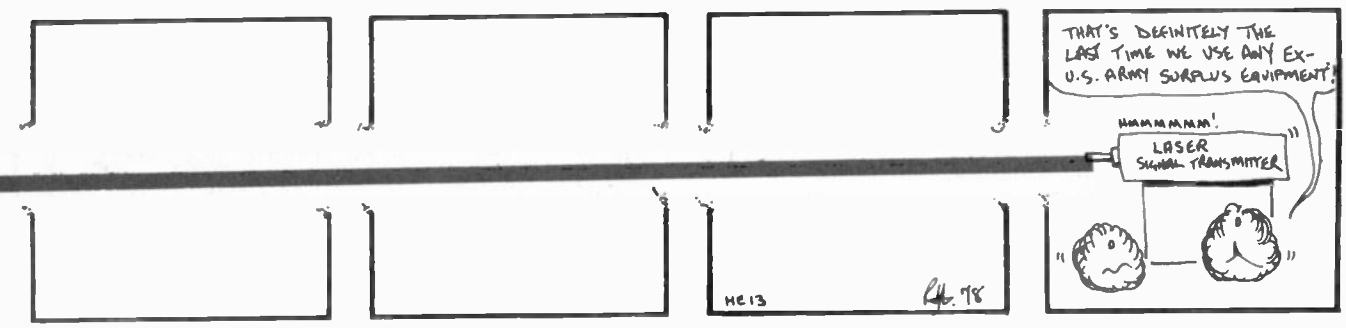
The death ray laser is not as far away as you might think, but it isn't hand held! As long ago as 1971, tests were made with 60kW lasers capable of igniting wooden targets at up to 4 kilometers. More recently we have heard a story (unconfirmable) about a 3 megawatt laser. It seems this huge beast is mounted in a converted passenger jet — with an extra engine to supply the power needed. The laser is a 192 foot carbon dioxide device, folded in order fit inside the aircraft. Because the beam from a CO_2 laser is infra-red (and can't be seen), a small visible laser is used as a 'tracker' beam — that people can follow the main beam.

One day the tracker laser was out of order, and someone moved the reflector to clean it. Unfortunately someone else switched the monster on — for a few seconds. The beam burnt a hole through the side of the hangar, two parked aircraft, another hangar wall (on the opposite side of the airfield) and two more aircraft — before finally stopping inside a fifth aircraft. Luckily nobody was in the way, as a three inch hole in your side is not much fun. As said we cannot confirm this story, but can well believe it!

So lasers can do many things, we have only mentioned a few of the many applications. Other uses include medical (eye surgery) engineering (levelling of building sites) and communication (a single laser beam can carry a million TV channels). A further use of lasers, and potentially the most exciting is holography — the subject of a future article in Hobby Electronics. **HE**

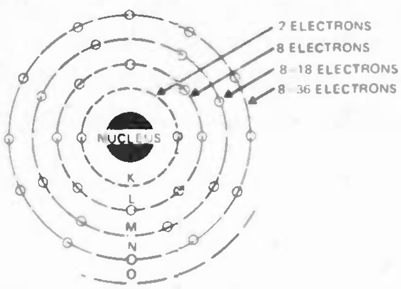


A laser rangefinder.



How it Works

To understand LASER action it is necessary to review atomic theory to some extent. All other electronic systems make use of the energy of free electrons in the atomic system. Lasers, on the other hand, use processes within the atom itself to produce coherent radiation.



The structure of the atom.

This diagram shows the now well known structure of the atom. This consists of a central nucleus orbited by one or more electrons. The complexity of the nucleus and the number of orbital electrons is unique to particular elements. The electron orbital paths are confined to discrete levels of shells, each shell corresponding to an energy level. An electron cannot exist in a stable state between shells and if subject to radiation that increases its energy it will jump to the next highest shell. The quantity of electromagnetic radiation necessary to just cause an electron to move to a higher shell is called a photon. Photons can be thought of as minute packets of energy which have the characteristics of both matter and electromagnetic radiation.

THE PHOTON

The Photon is a fundamental concept in the quantum theory and the relationship of the photon frequency and the energy level to which t atomic system is raised is given by the equation:

$$E = hv$$

where

E = Energy level in ergs
h = Planck's constant (6.624×10^{-27} erg-sec)
v = Frequency of the photon

A photon *of the right frequency* is therefore required to raise an electron of a particular atomic system to a higher energy level. When an atom is in its lowest energy state it is said to be in the ground state and when its energy has been increased by a photon it is said to be in an excited state.

From the excited state, a number of possibilities exist for the return to ground state. Firstly the electron may fall to an intermediate level and then to the ground state. A photon will be emitted at *each* transition having a *lower* frequency than the incident photon (because each energy level jump is smaller) or alternatively it may jump straight to ground state and emit a photon of the same frequency as the incident radiation. These mechanisms are known as SPONTANEOUS PHOTON EMISSION and normally occur very rapidly (less than a microsecond after excitation).

If a photon of the correct frequency is incident upon an atom already in the excited state, it will emit a photon having exactly the *same phase as the first photon, and travelling in the same direction*. This mechanism is known as STIMULATED EMISSION.

THE RUBY LASER

The original laser as built by Ted Maiman nowadays appears ridiculously simple. It consists of a ruby rod containing about 0.05% chromium (the chromium component gives the ruby its characteristic pinkish colour). The rod is surrounded by a Xenon flash lamp. The purpose of the flash lamp is to provide excitation, called pumping, at 5 600 angstrom (blue green light) to which the chromium atoms respond.

The chromium atoms, once excited, will spontaneously return to ground state in two steps. They first return to an intermediate level, known as the metastable state, with the emission of red light at 6943 angstrom.

At this point the ruby rod will glow with red light. The flash lamp continues to pump energy to the chromium atoms pushing more of them to upper energy levels until, *there are more atoms at the higher energy level than at the lower.* This is known as population inversion and at this point the operation suddenly changes. Now photons begin to interact with excited chromium atoms to a significant extent, with a resultant stimulated emission of other *identical* photons which travel in the same direction as the incident photons.

The ruby rod, which is several centimetres long and half a centimetre in diameter, will have some photons travelling parallel to its axis, and these will be reflected at the ends back into the crystal where they produce still more photons. Those travelling in other directions emerge from the sides and are lost. The build up of photons parallel to the rod continues until, at a critical point, some of the coherent radiation bursts out through the partially reflective end face. Thus, a laser pulse is born. The pumping process continues generating further pulses of coherent red light each having a duration of about one or two milliseconds.

Although such action is possible with a simple ruby rod having both ends polished and perfectly parellel to each other, it is far better to use external mirrors to do the reflection. These are specially constructed multilayer (dichroic) mirrors such that they reflect the frequency of interest with high efficiency. One of them is made partially transmissive to allow the laser pulse to emerge. For the laser to operate at maximum efficiency it is desirable to get as much light as possible into the ruby rod. For this reason the flash lamp is wound around the ruby in a helix.

Since Maiman's first laser began pulsing, some 13 years ago, enormous strides have been taken in the development of laser technology. Many new lasing techniques have been developed and both peak and average power have been increased to staggering levels.

Photocells

Photocells are the devices we use to detect light by making use of the energy that is carried by the light to generate an electrical signal. There's a remarkable number of different varieties of photocells, due to the fact that there's an equally remarkable number of substances which are affected by light. K. T. Wilson explains . . .

LET'S START with any solid-looking chunk of material. All these materials are made up of atoms which, in a solid material, are packed tightly together. These atoms, though, are hollow, mainly empty space, containing a positively-charged core called the nucleus and a lot of incredibly small negatively-charged particles called electrons. These electrons are involved in everything electrical or electronic (and a lot more besides).

Now we can get hold of electrons in comparatively small numbers, just a few millions at a time, and make measurements on them. We're pretty sure, as a result, that all electrons are identical. The electrons inside an atom don't behave as if they are identical, though, because some can be removed much more easily than others. We explain this by saying that the electrons have different energy levels, meaning that some are much more tightly held by the attraction of the nucleus than others. This idea of energy levels is probably one of the most important ideas of modern physics, and it's practically impossible to discuss why electronic components behave as they do without bringing in energy levels somewhere.

LIGHT READING

What about the light, then? Light, like radio, is an electromagnetic wave. That, translated a bit, means that where you have a light ray there's a voltage oscillation and a magnetic oscillation as well. It's the voltage oscillation that we're interested in — that's the one we pick up in an aerial when we receive a radio broadcast. What happens in an aerial is that the electrons in the metal follow the oscillations of the voltage wave, so that an alternating voltage is created in the wire. That's the radio signal that we detect and amplify.

Now we come across one of these horses-for-courses choices. We find electromagnetic waves at all sorts of frequencies, from a few hundred kHz (long waves), through the UHF band of several hundred MHz, past the much higher frequencies of light waves and beyond. These waves all have two things in common — they travel at the same speed in space — about 300 million metres per second — and they are all emitted in bunches, not continuously. Each bunch of waves carries a definite amount of energy, an amount that depends on the frequency of the waves in the bunch. A bunch of light waves at a frequency of 6 hundred-million-MHz therefore carries a lot more energy than a bunch of medium-wave radio waves at 1 MHz, and it's this bunch energy called the quantum energy (the word quantum just means bunch) that has an effect on materials.

Measured in this way, radio waves are rather feeble things, just about able to carry out the easy job of moving electrons in wires. Light waves carry a lot more quantum energy, and the energy of one of these bunches of light waves *can* be enough to shift an electron from its own energy level to the next higher one. Can? Yes, because the gap between energy levels is not the same for all substances and only some of the millions of substances we know have just the right arrangement of electrons for packets of light waves to shift one.

The first substance discovered behaving in this way was the element selenium. Selenium is photovoltaic, meaning that the effect of light is to free electrons completely from their atoms. If a piece of selenium is part of a circuit, then the action of light on the selenium is to make it behave like a battery, causing current to flow in the circuit. Selenium is still used for light-measuring meters, but more modern photovoltaic cells, based on another semiconductor, silicon, have been developed. It's these silicon cells which are our main hope for generating electricity direct from sunlight, incidentally, so that there's a lot of research going on at the moment.

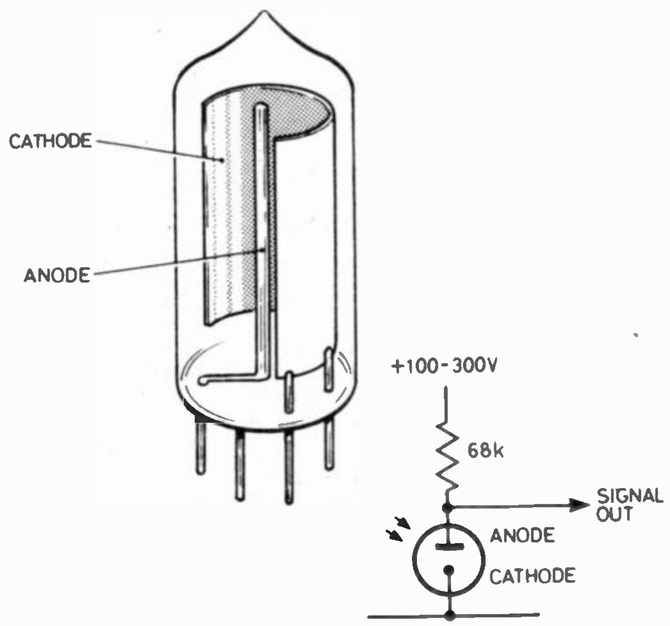


Fig. 1. A vacuum photocell, and typical circuit.

PHOTO EMISSION

A few substances have electrons with such low energy levels that electrons can be shot out at high speeds when a light beam strikes the material. Materials like this are called photoemissive, but they can be used only in a vacuum. There are two reasons for this. One is that the materials themselves are chemically attacked (oxidised) by air; the other is that the electrons that are released can't get very far if the material is surrounded by air. A vacuum photocell contains a photocathode — a nickel plate coated with the electron-releasing material such as the metal caesium — and an uncoated anode, both inside a bulb from which the air has been removed. To use the cell, a voltage of 90 to 200 V is connected across the terminals (anode positive). When light strikes the photocathode, electrons are released and are attracted to the anode by the positive voltage. The current that flows in the circuit can be detected by a microammeter; it's small but it's there. This type of vacuum photocell was once the main method of detecting light, particularly of rapidly-changing pulses of light such as those from the sound track of a movie film. What made the vacuum photocell particularly suitable was its quick response — there was very little time between starting or stopping the light and starting or stopping the current. Very little time means less than a microsecond, in contrast to the selenium cell which takes about a quarter of a second to respond either way.

Fig. 2. The Cadmium Sulphide LDR, and symbol.

For many years, the selenium cell and various forms of vacuum photocell were the only types of photocells we knew — then the semiconductor age began. We've learned so much about energy levels and how to play with them that a whole new set of photosensitive materials has been invented. Semiconductor materials have their energy levels arranged so that only a small amount of energy is needed to release an electron, allowing the material to conduct better. This process is called electron-hole pair production, because each electron that is released leaves a space, called a hole, in the crystal structure of the semiconductor. The holes behave like conducting particles, assisting the material to conduct. Let's see how this process is used in modern semiconductor materials.

HARD CELL

One of the most familiar cells is the cadmium sulphide photoconductive cell. Cadmium sulphide is a material that can be evaporated onto any smooth surface, so that it's easy to make into a thin film; cadmium sulphide photocells (often called LDRs — light dependent resistors) use tracks of film of the shape shown in Fig. 2. We can make electrical connections to each end of such a track, so that the cell can be wired into a circuit as if it were a resistor. In darkness, the cadmium sulphide is practically an insulator, and a cell will have a resistance of 1M or more. Light falling on the material causes electrons and holes to separate, so that the material conducts, and the resistance falls very greatly, to 1k or less depending on the width and length of the track.

Cadmium sulphide cells have some peculiar advantages and disadvantages compared to other types of cells. They can be used in circuits where quite high voltages exist, 300 V for some types of cells, so that these cells can be connected directly across the mains supply. They can also pass quite large currents, so that relays can often be driven directly with no need for transistors.

Photodiodes and phototransistors are the other important classes of modern photocells. Unlike the cadmium sulphide photocell, which consists of a single material, a photodiode has a PN junction. P-type semiconductor material conducts mainly by hole movement, N-type mainly by electron movement, and we can form thin films which are P-type on one side and N-type on the other, with an electrical contact to each. This is, of course, the familiar junction diode, and a diode like this which is reverse biased does not normally conduct because the voltages that are applied have the effect of pulling the holes and electrons away from the place where the two types meet, the junction.

If light hits the junction, though, electron-hole pairs are generated and the junction becomes conducting. With a steady voltage across the junction, a current will flow when the junction is illuminated. The current is small, only a few microamps, but the response speed is very fast, measured in nanoseconds. (1 ns = 10^{-9}s). Photodiodes of this type, plus fast pulse amplifiers are the natural choice for detecting very short flashes of light.

PHOTOTRANSISTORS

The phototransistor is the type of light detector which is chosen for most applications that don't need ultra-high speed or very large currents. A phototransistor is constructed in the same way as any other transistor, with the sandwich of PNP and NPN semiconductor materials. In the dark, it'll work away like any other transistor, with

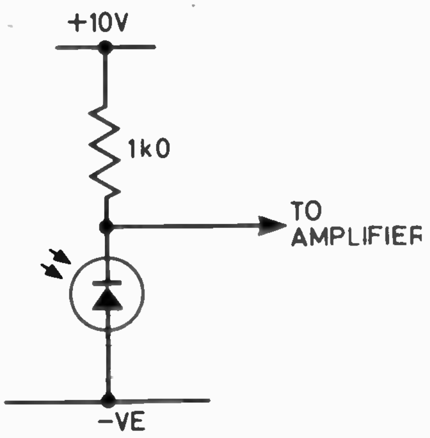


Fig. 3. The photodiode symbol and typical circuit. Though the action of the cell is fast, the maximum frequency of operation is limited by the capacitance of the diode, typically 1 nf (1 000 pF).

the current between the base and emitter layers controlling much larger currents between the collector and emitter layers. In the light, though, interesting things happen — as the advert says! A phototransistor is operated with no connection made to the base — some phototransistor types have no base connection terminal. Now if you operate an ordinary transistor in this way, nothing happens, because it's the current into the base terminal which fills up the base-to-emitter junction with electrons or holes and so makes the lot conduct. A phototransistor is constructed so that light can reach this base-emitter junction, and the light will have the usual action of separating electrons from holes at the junction. Now neither of these can flow to the base contact, because it's disconnected, so that the only possible direction is towards the emitter or the collector.

Suppose the phototransistor is an NPN type, with the collector voltage positive and the emitter voltage negative. When an electron is separated from a hole at the base-emitter junction, the electron will head towards the collector, but the hole isn't so lucky. At the start, there's practically no voltage between the base and the emitter, so there's no reason for the hole to move. The result is that the base gets more and more positive as it

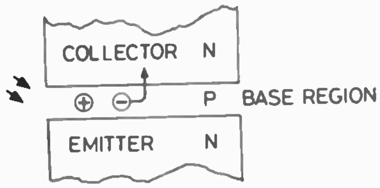
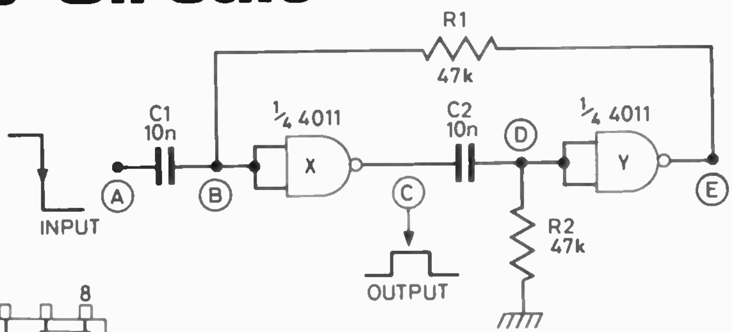


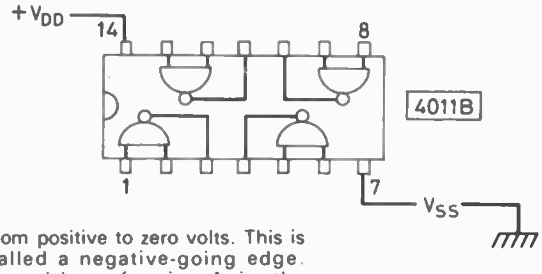
Fig. 4. The phototransistor — symbol and arrangement of junction.

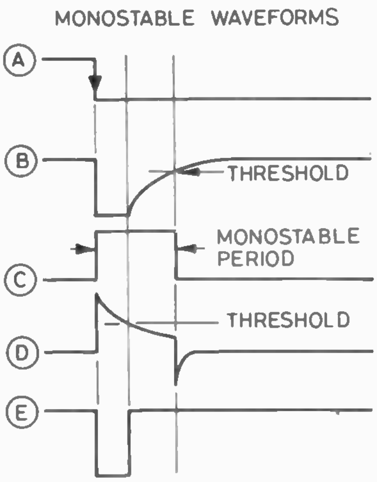
loses electrons and hoards holes. Pretty soon, this positive voltage does exactly what positive bias does to an ordinary transistor — it attracts electrons from the emitter. Most of these electrons go straight to the collector, though, because the base layer is so thin, and the phototransistor then passes several milliamps of current between collector and emitter just to make sure that a few microamps flow to the bass. The result is a photocell which can pass much higher currents than a photodiode, though with a slower switching speed. **HE**

Short Circuit

CMOS MONOSTABLE







A monostable is an electronic circuit that generates an output pulse of defined duration, when triggered by an input signal transition. The monostable action can be used for many different functions, for example: When a cheap push button is used to trigger digital circuitry, spurious pulses often find their way into the circuitry. This is due to the contracts inside the button bouncing, when it is pressed and released — digital circuitry will regard all of the bounces as valid input signals, and act accordingly — this can be disasterous in counting applications. A monostable can be used to 'debounce' the push button. By setting the output pulse duration for a period longer than the longest expected bounce time, all the bounces will gave no effect on the main circuitry. So with a simple monostable between each push button and the input circuitry, the digital devices are protected from the horrors of untamed push buttons. There are hundreds of other uses for the monostable, this circuit is one of the cheapest way of constructing them.

Only two inverters are needed for a monostable circuit. Here, we have used a 4011B quad NAND package, as they are even cheaper than a CMOS inverter package and work just as well.

The monostable period is initiated by the transition of point A from positive to zero volts. This is called a negative-going edge. Transition of point A in the opposite direction (a positive-going edge) will have no effect.

A negative edge at A causes point B to go to zero volts momentarily. This will then drive point E to zero and this will hold point B at zero volts, even when the pulse at A is finished. The circuit will stay in this state while C2 charges. When C2 is fully charged, there will no longer be a current through R2 and point D will fall to zero again. E will go positive and so will B, after a time determined by the values of C1 and R1. Point C will fall to zero and C2 is fully charged, there will no longer be a current through R2 and point D will fall to zero again. E will go positive and so will B, after a time determined by the values of C1 and R1. Point C will fall to zero and C2 will be discharged, ready for the next pulse from A.

A length of time for which C remains positive is determined by the values of C1, R1, C2 and R2. This is called the 'time constant'. If either the resistance or the capacitance is increased, the time for which the monostable is 'triggered' will increase.

The equations for calculating the monostable period are given on the circuit diagram. Polarised capacitors should not be used, and the resistance value of R should be kept within the range 10k to 10M.

If R1 = R2 and C1 = C2 then typical values are 10mS 100k, 68p; 10mS 1MO, 6n8.

MONOSTABLE PERIOD τ

τ = 0.69(R1 x C1 + R2 x C2)

IF R1 = R2 AND C1 = C2 THEN

τ = 1.38(R1 x C1)

IF R = 47k, C = 10n THEN τ = 0.7 mS.

Radio Servicing Tips

Here are ten effective ways to help you locate radio faults faster. They are usually obvious (though often unremembered) ideas that have been used and proved profitable. By Terry L. O'Connor.

1. Check Battery Voltage and Current

Make this a regular procedure. Test receiver battery voltage with it turned ON. Check the current drain with the volume control turned down. The current drain may be checked by placing a milliammeter (most multimeters have a milliamp range) across the receiver's on/off switch terminals (set off). The average transistor radio may draw some 5 to 15 mA if it uses Class B output stages and somewhat more if the output stage is Class A.

Excessive current drain may be caused by shorted or leaky bypass capacitors, incorrect biasing of one or more transistors or by a defective transistor.

2. Find the Obvious Faults

Possibly more than anything else, transistor radios suffer from broken wires and terminals usually caused by the owner dropping the radio. Broken wiring may be quite difficult to analyse, either by signal tracing or voltage readings. A lot of time can be saved by visual checking. The use of an illuminated magnifier can help find broken conductors.

Try slightly flexing the printed circuit board to find tracks that are broken or intermittent. Small resistors are easily cracked and often go open circuit.

Heavy components, such as transformers, often pull away from the printed board and break their connecting leads in the process. Try moving each part from side to side gently and listen for a pop in the speaker. Use a jumper wire with needle point probes at each end to check if the printed track is open.

3. Don't worry about transistors or ICs.

Not at first anyway. It is just an advertising agency's dream — bad transistors or IC's *do* account for only 2 to 3% of all transistor radio defects — check other things first.

Also check earphone sockets — the type which switch off the speaker sometimes leave it off!

4. Don't rely on transistor gain checks

Unless there is laboratory equipment available, your chances of learning anything from a gain check are nil. The DC gain has almost nothing to do with the manner in which a transistor will perform in a practical RF circuit. There are too many other factors involved, such as input and output impedance or biasing.

5. Check transistors with an in-circuit transistor

As the transistors used in portables usually are not plugged in, we must have some exploratory method for checking that does not mean unsoldering the transistor. The quickest way is to use an in-circuit transistor tester, available from many radio components retailers. However, if you do not own a transistor tester (in-circuit variety) you can use a multimeter instead.

With the radio off, place an ohm-meter (20 000 ohms per volt or better) across the Base and Collector of the transistor; and reverse the test leads. There should be more resistance in one direction than in the other. Do the same from Base to Emitter. Typical readings may be 3,000 ohms in one direction and 20 ohms in the other. This usually indicates that the transistor is good, as there is evidence of diode action.

A transistor can also short circuit from Collector to Emitter, without affecting the apparent diode action of the Base-Collector, Base-Emitter paths.

6. Signal Trace or Signal Substitute

You can use a signal generator for signal tracing. Start with the audio and successively trace backwards towards the front end. Never be tricked, though, by the low-impedance base circuit of a transistor. It will greatly attenuate the signal generator's output. Always inject the signal into the higher impedance collector circuit, if possible.

7. Never Be Tricked by Gain of Receiver

A transistor radio may appear to be operating normally especially on strong local stations, but refuse to work when taken to a fringe area. If you work quite a lot on the same kind of radio, you may set up tests with an output meter and your signal generator to determine if the gain is up to scratch. If it is not, check the tuning and tracking (as detailed in TIP 10). Use a substitute capacitor and *shunt* each and every bypass and coupling capacitor in the radio.

Capacitors and IF transformers can cause more weak radio faults than anything else. Transistors can short or open. Try to check IF's by re-tuning them. If they cannot be peaked, they are faulty. If the tuning has to be changed drastically (unless the radio has been tampered with by someone), it is likely the IF transformer is defective and will have low gain, even though it may appear to peak at some position of the slug.

8. Check the Oscillator With Another Radio

Position a working radio, tuned to a station at the high end of the band, near the radio with a suspected oscillator stage. Sweep the defective radio through its tuning range. At some point a whistle or squeal should be heard in the good radio if the defective radio's oscillator is operating. This whistle or squeal should be heard at approximately 455 kHz below the station tuned in on the good radio, if the good radio uses a 455 kHz IF (most do). This allows you to know that the oscillator tuning circuit on the defective radio is operating.

It is also possible to use a peak-to-peak meter or a wide-band oscilloscope (even some narrow band scopes) to test oscillator action. Most radios should develop approximately 0.2 to 0.8 volts peak-to-peak at the base of the oscillator transistor.

9. Take Accurate Voltage Readings and Reason Out the Fault

More than half of the tough transistor radio faults may be diagnosed by voltage readings. Remember, with respect to the Emitter, the base is the *same* polarity as the Collector. If the collector is positive then the base will be positive; if it is negative the base will be negative, unless there is a fault. The bias voltage between the emitter and base is often 0.2 volt or less, but the base must have the same polarity as the collector. In a typical example Base to Emitter 0.2 volts, Collector to Emitter 3.5 volts. Another example Base to Emitter — 0.4 volt, Collector to Emitter — 5.5 volts.

Now let us suppose that these readings were obtained —

Base to Emitter	plus 0.2 volts
Collector to Emitter	minus 6 volts

It is obvious that the base and the collector are not of the same polarity. The transistor cannot operate; it is cut off.

An open transistor can be found because there is no voltage drop across the emitter resistor. Of course, you shall always check the bias first, as incorrect bias will cause the emitter resistor voltage to drop to zero.

CAUTION. When taking bias readings, watch out, for some receivers will have practically no (or even reverse) DC bias on the converter stage, when it is also used as an oscillator. You may think that the transistor cannot operate, but it does so because of the AC bias developed by the oscillatory circuit.

10. Use a Noise Source to Align Oscillator and Antenna Circuits

Firstly align the IF's with an accurate signal generator to their specified frequency.

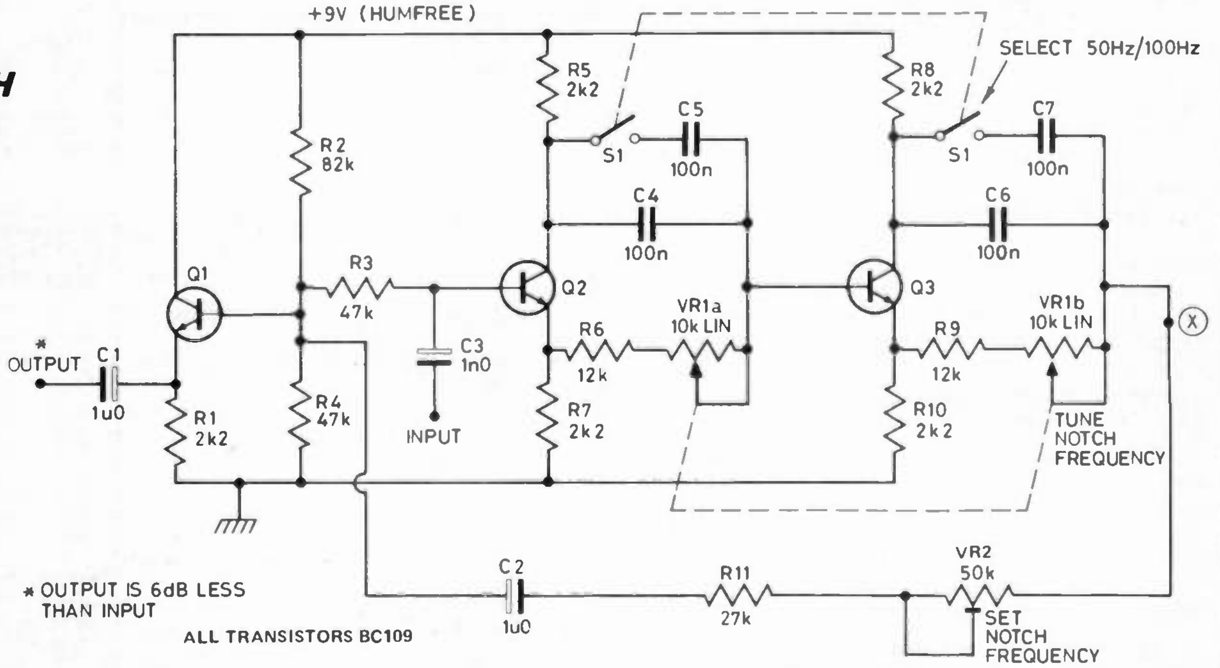
Second, use a Noise Generator (or a fluorescent lamp), and placing the radio close to the noise source, tune in to the low frequency end of the band and adjust the oscillator coil for maximum noise.

Third, now tune the radio to the high frequency end of the band and adjust the antenna trimmer for maximum noise.

If calibration is off somewhat, you can touch up the oscillator trimmer, then repeat the above steps.

Short Circuit

HUM NOTCH FILTER

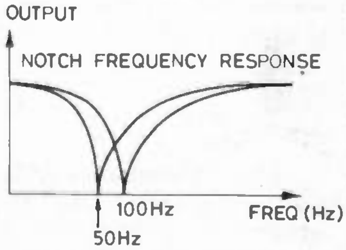


Mains hum only comes from one source — the electrical mains. However there are many ways it can get into an electrical circuit (particularly those that deal with low level signals), and it is in these circuits that a hum notch filter can sometimes be needed.

There are two types of hum, interference from magnetic sources (such as transformers) and ripple on the supply line (because of poor power supply regulation). Magnetically induced hum is generally at a frequency of 50Hz, while ripple hum is mainly at 100Hz. This circuit can deal with either of these types of hum, with the selection of 50Hz or 100Hz operation by a switch.

The unwanted hum is attenuated by passing the signal through a notch filter, operating at the hum frequency. The filter is made from two transistor stages which each delay the signal by 90°, the total delay through Q2 and Q3 is therefore 180° at point X. The delay only affects the hum part of the signal, and this delayed (or rather, phase shifted) hum is mixed back into the main signal via RV2. The hum in the main signal is cancelled by the 180° shifted hum, and the other (wanted) signal is virtually unaffected. RV1a, b is used to vary the centre of the notch frequency, by plus or minus 40%. With the switch open circuit the frequency of operation is 100Hz.

Of course the best way to eliminate hum is to prevent it creeping in at all. This can be done by careful smoothing and regulation, of the power supply — and careful electrical screening of all mains (or low voltage AC) leads. All items of equipment should be earthed at one point only internally, and any internal lead with a screen should only have the screen connected at one end. Also in a system only one item should be connected to the mains earth, all the other equipment must use it as their route to earth.



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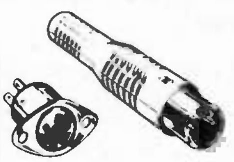
3.5mm	9p	14p	8p
Standard	16p	30p	15p
Stereo	23p	36p	18p

Din plugs and sockets



	plug	socket
2 pin speaker	7p	7p
3 pin	11p	9p
5 pin 180°	11p	10p
5 pin 240°	13p	10p

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0.1in 35p
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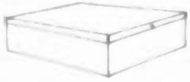

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BC108	8p	BD140	35p	2N3053	18p
BC109	8p	BF244B	36p	2N3055	50p
BC147	7p	BFY50	15p	2N3442	135p
BC148	7p	BFY51	15p	2N3702	8p
BC149	8p	BFY52	15p	2N3704	8p
BC158	9p	MJ2955	98p	2N3705	9p
BC177	14p	MPSA06	20p	2N3706	9p
BC178	14p	MPSA56	20p	2N3707	9p
BC179	14p	TIP29C	60p	2N3708	8p
BC182	10p	TIP30C	70p	2N3819	22p
BC182L	10p	TIP31C	65p	2N3904	8p
BC184	10p	TIP32C	80p	2N3905	8p
BC184L	10p	ZTX107	14p	2N3906	8p
BC212	10p	ZTX108	14p	2N4058	12p
BC212L	10p			2N5457	32p
BC214	10p			2N5458	30p
BC214	10p			2N5459	32p
BC477	19p			2N5777	50p
BC478	19p				
BC479	19p				
BC548	10p				
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LS10	16p	LS138	54p
LS13	30p	LS139	50p
LS14	70p	LS151	50p
LS20	16p	LS153	50p
LS30	16p	LS155	80p
LS32	24p	LS156	80p
LS37	26p	LS157	45p
LS40	22p	LS164	90p
LS42	53p	LS174	60p
LS47	70p	LS175	60p
LS48	48p	LS190	80p
LS54	16p	LS192	70p
LS73	29p	LS193	70p
LS74	29p	LS196	80p
LS75	44p	LS251	60p
LS76	35p	LS257	55p
LS78	35p	LS258	55p
LS83	60p	LS266	40p
LS85	70p	LS283	60p
LS86	33p	LS290	55p
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CA3046	55p	LM1830	150p	SN76013	140p
CA3080	70p	LM3900	50p	SN76023	140p
CA3130	90p	LM3909	60p	SN76033	200p
CA3140	70p	MC1496	60p	TBA800	70p
LM301AN	28p	MC1458	35p	TDA1022	650p
LM318N	125p	NE555	25p	ZN414	75p

TTL

7400	12p	7493	34p
7401	12p	7494	52p
7402	12p	7495	52p
7404	12p	7496	50p
7408	14p	74121	25p
7410	12p	74122	33p
7413	25p	74123	40p
7414	48p	74125	35p
7420	12p	74126	35p
7427	24p	74132	50p
7430	12p	74141	56p
7442	43p	74148	90p
7447	55p	74150	70p
7448	58p	74151	50p
7454	14p	74156	52p
7473	25p	74157	52p
7474	25p	74164	70p
7475	32p	74165	70p
7476	28p	74170	125p
7485	70p	74174	68p
7489	145p	74177	58p
7490	32p	74190	72p
7492	35p	74191	72p
		74192	64p
		74193	64p
		74196	55p
		74197	55p

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LEDs	0.125in.	0.2in.	
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4002	15p	4040	68p
4007	15p	4042	54p
4011	15p	4046	100p
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4015	60p	4050	28p
4016	35p	4066	40p
4017	55p	4068	20p
4018	65p	4069	16p
4023	15p	4071	16p
4024	45p	4075	16p
4026	95p	4093	48p
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			220			20p
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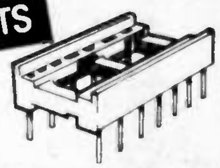
	100					8p
		220				10p
				470		15p
	1000					23p
10V		220				5p
				470		9p
	1000					13p
		2200				23p

SKTS



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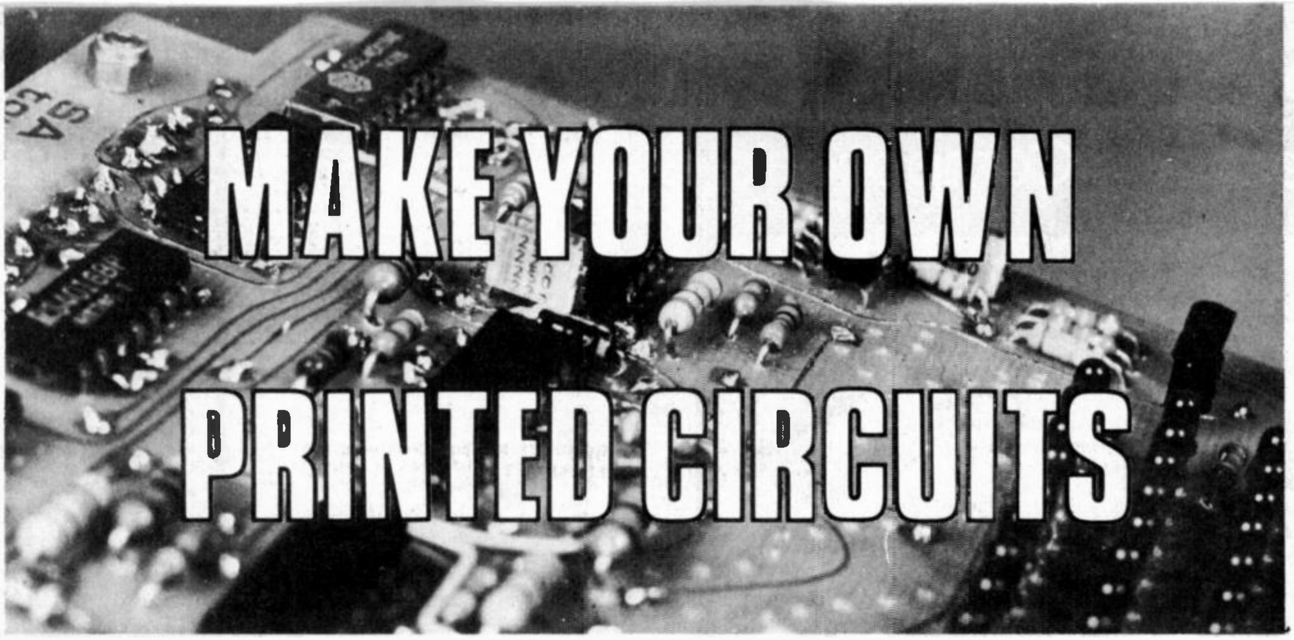
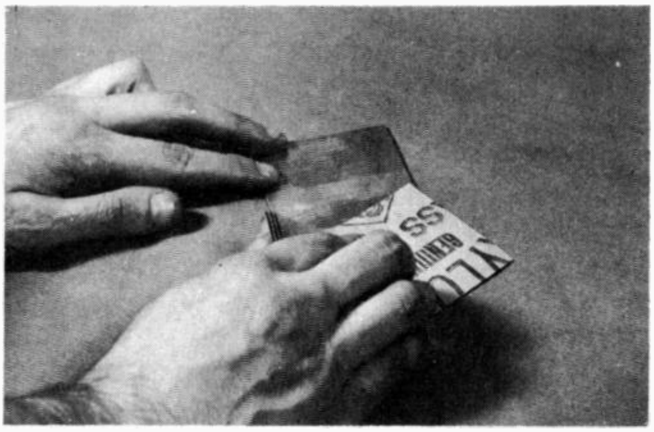


Making printed circuit boards is simple and makes project-building easier and the projects more reliable. Phil Cohen shows how it's done.

IN ORDER TO AVOID using large numbers of wires to connect components together — which is a very costly, time-consuming and error-prone method — manufacturers of electronic equipment almost invariably use printed circuit boards (PCBs). These consist of a sheet of "synthetic resin bonded paper" (usually referred to as SRBP, for obvious reasons) on which there are copper tracks to connect the components electrically. The component wires are pushed through holes in the PCB and soldered onto the copper tracks on the other side (see facing page). This means that the components are connected together (with little possibility of error) and supported mechanically at the same time. This technique is not confined to industrial use, however, and many electronics enthusiasts use it to great advantage.

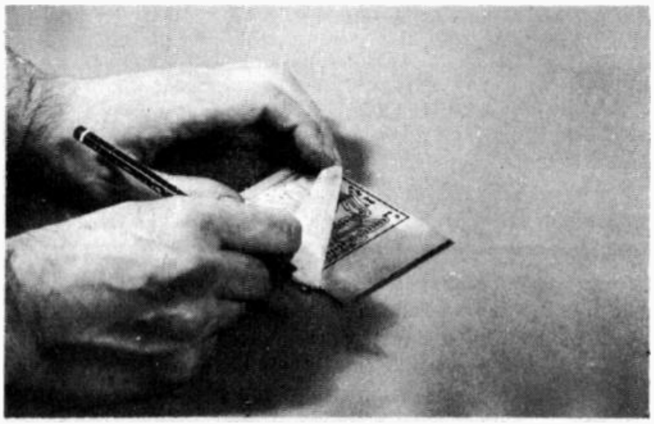


Clean the copper side of the board with sandpaper — be careful not to touch the cleaned surface, as this will cause trouble in later stages.

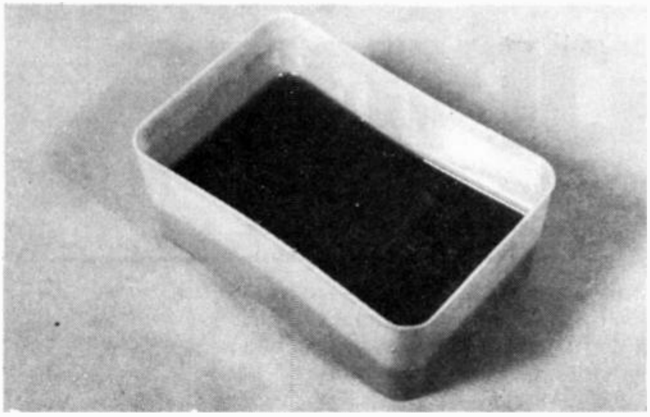
WHAT YOU NEED

Although ready-made printed circuit boards are available for many Hobby Electronics projects (see advertisers in this issue), they tend to be rather expensive — although otherwise excellent — and many people may prefer to make their own. This can be done very cheaply with only a small outlay, the most expensive

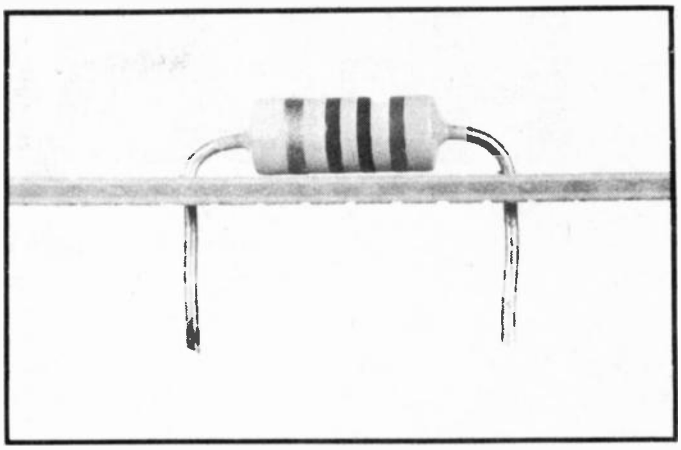
item being a miniature drill. The other items required are a blank copper-clad board, an etching tray (must be plastic) and a quantity of ferric chloride etchant. These are all obtainable from electronic component stockists. The appropriate "HOBBY-PRINT" (as advertised in this issue) is also required, although those of you intent on doing things the hard way *could* use a PCB marking pen.



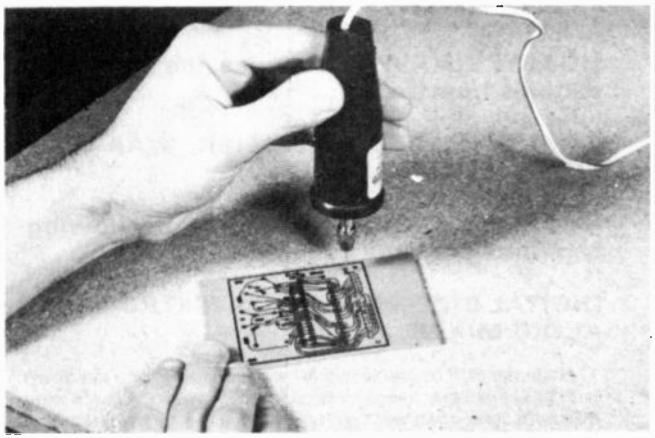
Rub down the HOBBY-PRINT: This is done using a soft pencil. The parts of the HOBBY-PRINT which stick to the board will protect the copper from the etchant. A PCB marking pen *could* be used at this stage, but the pattern would have to be copied by hand (the pen is of the felt-tipped variety, filled with a substance which will resist the action of the ferric chloride when dry).



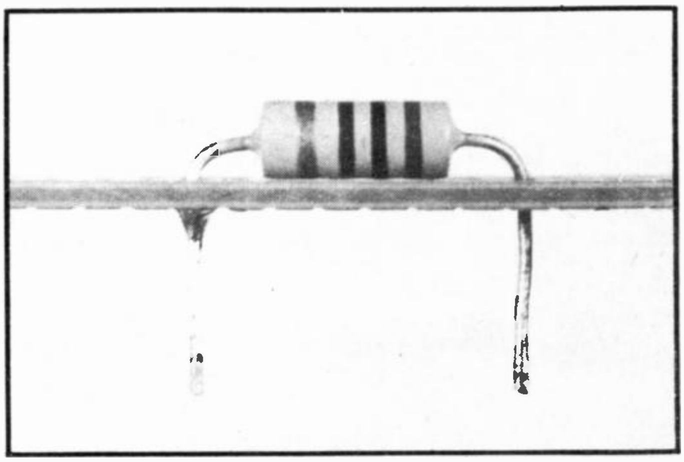
Etch the board: Following the instructions on the etchant bottle, dilute enough of the etchant to half-fill the tray. Put the board in the liquid *copper side down* and prop up one end of it with something non-metallic. Leave it for about 15 mins. The copper reacts to form a black powder which floats to the bottom of the tray.



Insert the components one by one and solder them in. Be careful not to bend the wires too close to the component body as this may damage it.

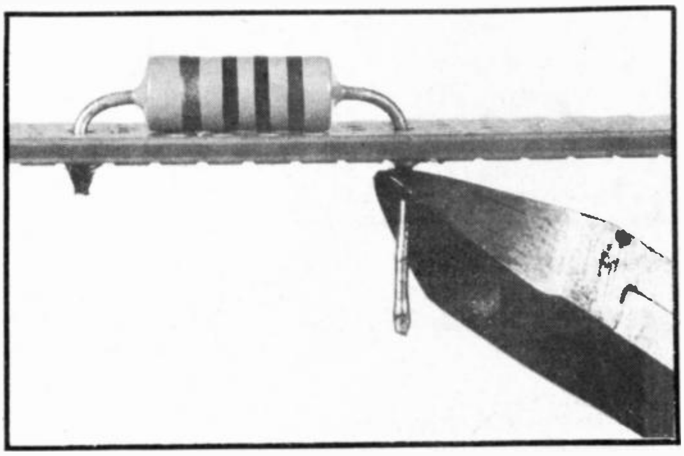


Wash the board thoroughly (the etchant will stain clothes and may be harmful to the eyes) and then drill the holes for the component wires. Small battery-driven drills can be bought which are ideal for this purpose.



Solder the wire onto the copper strip — apply the solder and the soldering iron at the same time. The solder should flow evenly over both the wire and copper track. Allow the solder time to solidify (about 5 seconds) before moving the board.

Clean the resist from the board, again using sandpaper. It is worth doing this thoroughly, as the board may otherwise be difficult to solder. Inspect the board carefully — there may be small breaks in the copper "tracks" due to scratches in the HOBBY-PRINT after it has been applied, or "bridges" from track to track due to fingerprints on the board before etching. Solder across any gaps and scrape away bridges.



Trim the wires to length. This can be done using a pair of "side-cutters" as shown. Be sure to trim down to where the solder begins, to prevent the wire ends from touching each other when they are positioned closely on the board.

HE

Hobbyprints

An easy, patented method of making PCBs for HE projects.

For some time it has been possible to buy acid resist rub-down pads and track — in fact we use them in the HE workshops and they work very well. HOBBYPRINTS take this idea a stage further — the complete PCB pattern is already on the sheet and can be rubbed down in seconds — and the patterns are nice and crisp, made from the original artwork, used for the prototype.

If you have the facilities for ultraviolet exposure, HOBBYPRINTS make excellent masters — being solid black on a translucent film. With this method you can use the HOBBYPRINTS time and time again!

HOBBYPRINTS are produced exclusively for HE, and the whole system is protected by patents 1445171 and 1445172. Each month we will be bringing out a new HOBBYPRINT, containing the patterns for each issue's projects.

HOBBYPRINT A — contains the following patterns from issue 1:

5 WATT STEREO AMPLIFIER, WAA-WAA PEDAL. BEDSIDE RADIO.

HOBBYPRINT B — contains the following patterns from issue 2:

DIGITAL DICE. PHOTON (2). METRONOME. AUDIO MIXER.

1. Clean the PCB as you would for any work giving it a rub down with fine sandpaper (we even supply this in the kit). A quick wipe over with lighter fuel will help to remove any grease marks.

2. Lay down the HOBBYPRINT and rub over with a soft pencil until the pattern is transferred to the board. Peel off the backing sheet carefully making sure that the resist has transferred. If you've been a bit careless there's even a 'repair kit' on the sheet to correct any breaks!

3. Cut the board to size and put it in the Ferric Chloride.

4. When etching is completed, wash the board and use the sandpaper or a scouring powder to remove the resist. The resist pattern is pretty hardy but is easily removed at the final stage.

5. All you've got to do now is drill the board. Time? Only about ten minutes from beginning to end plus etching time (15 minutes usually with a good acid).

ORDER TODAY

Send cheque or postal order (payable to Hobby Electronics) to:

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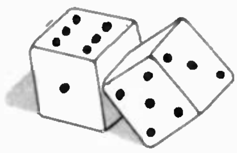
HOBBY ELECTRONICS,
25-27, OXFORD STREET,
LONDON W1R 1RF.

75p INCLUSIVE OF VAT AND POSTAGE.

Please mark the letter(s) of the HOBBYPRINTS on the outside of the envelope.

Push-Button Dice



We think this project will be a winner . . .

GENERATORS OF RANDOM NUMBERS in the range one to six (dice to most of us), are essential items in games ranging from Ludo to Backgammon. This is fortunate for those us who count electronics amongst our hobbies. Why? you ask, well the answer's simple. When asked what your hobby is, if in reply you answer electronics, as often as not this will be greeted with a yawn, pictures of boring theory and mountains of test geat being conjoured up by the questioner. Bring out an electronic game, however, and all this changes. Electronics can be fun.

NEVER SAY DIE

Unfortunately, most games, in order to be interesting, involve a lot of different factors that our electronics must keep track of. This, in terms of 'hardware' means lots of lamps, switches, and wire — complications. Happily, to build a dice, if our plans are followed, is an easy task, and will impress your friends as it is a distinct improvement over the traditional spotty blocks of wood.

STRAIGHT AS A DIE

Our photographs show that our die is built into a small box that has a line of Light Emitting Diodes (LEDs) to represent the six numbers plus a push button. Operating the button will activate the circuit and when the button is released one of the six LEDs will be lit, the particular one being impossible to predict. The LED will stay on for about five to ten seconds before going out. The dice is now ready to be "rolled" again.

The dice does not have an on/off swich, as with the LEDs off the circuit draws such a small amount of current from the battery that such a swith is not necessary.

CONSTRUCTION

As with any project, the exact method of construction is largely a matter of personal choice. The photographs clearly show how our dice went together, but there is no reason why you should not put your project in a different type of case. At any rate the first thing to do is to assemble the PCB according to our overlay.

The dice uses a type of IC known as CMOS and this reason we suggest that you use IC sockets when building the project as CMOS ICs are more electrically 'fragile' than other types of IC.

When mounting the components, make sure that the ICs and the electrolytic and tantalum cpacitors are fitted

Parts List

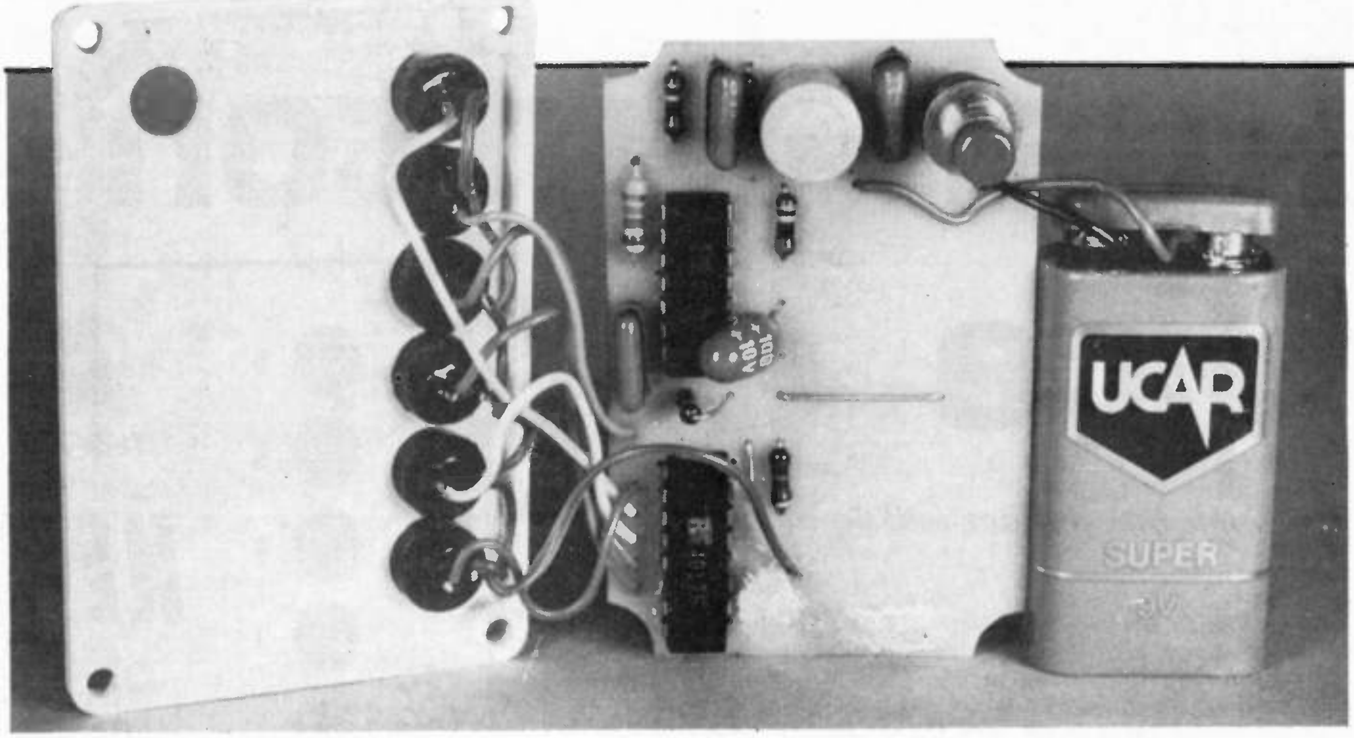
RESISTORS (all ¼w 5%)		
R1, 3, 5	100k	
R2	10k	
R4	56k	
R6	470R	
CAPACITORS		
C1	100n	polyester
C2	100u	16V electrolytic
C3, 5	10n	polyester
C4	100u	35V tantalum
SEMICONDUCTORS		
IC1	CD4011B	
IC2	CD4017B	
LEDS 1-6	TIL209	
SWITCH		
PB1	Miniature push to make	

MISCELLANEOUS
PCB as pattern, PP3 battery plus clip, Vero box, wire, etc.

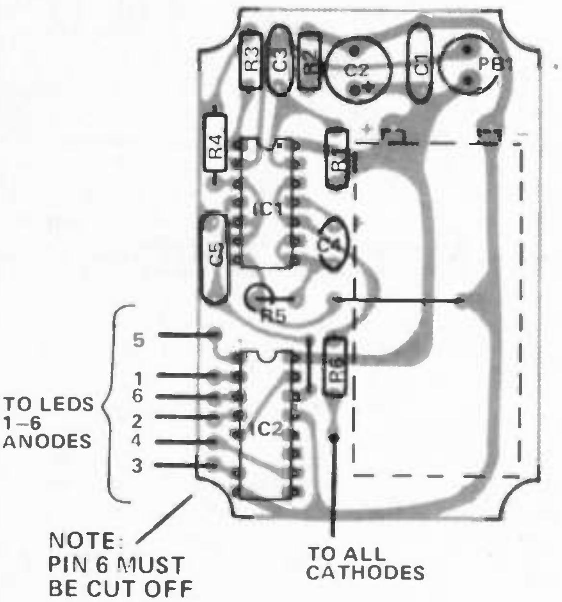
The ICs used in the LED dice are digital CMOS devices, the letter B after the number referring to the fact that the IC features protection devices at its input. Do not worry if the letter B does not appear in the adverts for these ICs as most CMOS devices on sale today are of the B series.

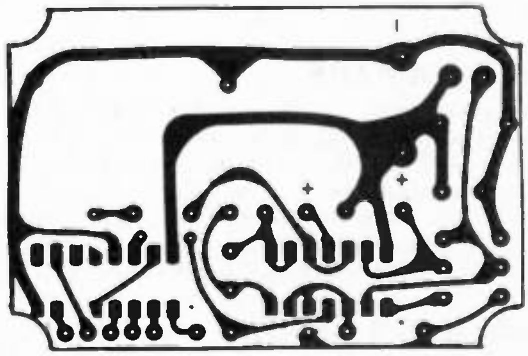
Careful scanning of the adverts in this issue of Hobby Electronics should locate suppliers for all of the components used in the LED dice.

Approximate cost £4.50.

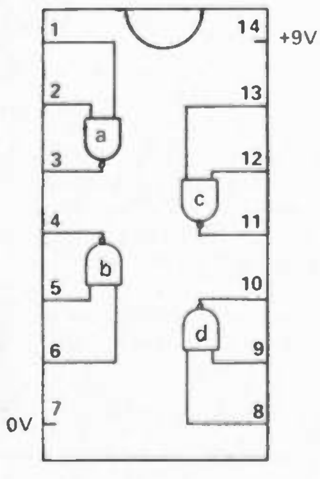


***ABOVE:** the case opened to show what makes the dice tick. **LEFT:** the 'component overlay' which links the circuit diagram with the above photo. **BELOW:** the pattern for the copper foil side of the printed circuit board.*





Below: Pin out data for IC1 and LEDs 1-6.



a = ANODE
k = CATHODE

the right way round. Failure to do so will result in a dead LED dice.

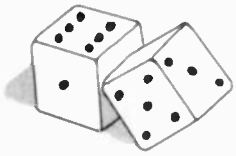
When marking out the front panel take care that the LEDs are in a straight line. The LEDs are mounted with special mounting clips that should be available from the people who supply the LEDs themselves.

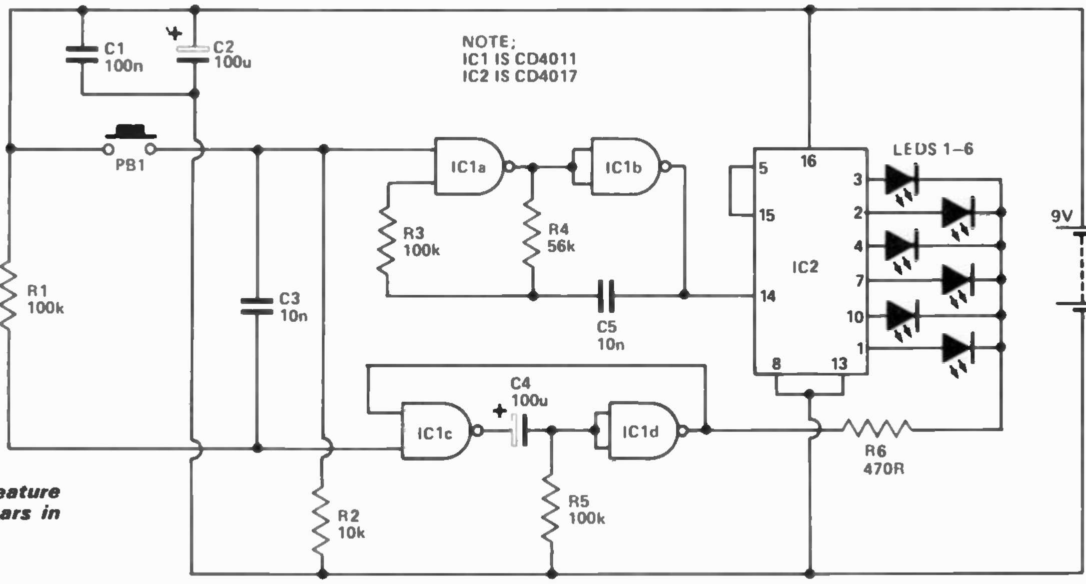
There is a fair bit of wiring to do so take care when doing this job. It's easy to make a mistake here, and any error can take a long time to find.

When all construction is complete, fit the battery and get ready to roll your first electronic die. **HE**

***LEFT:** Some tantalum capacitors are not marked with a "+" as in the photo. They instead have a dot on one side only.*

Push-Button Dice





The circuit diagram. A feature on circuit symbols appears in this issue.

How it Works

THE digital dice, in order to simulate the action of a real die, is required to "stop" with one of the circuit's six light-emitting diodes (LEDs) lit, each LED corresponding to one of the six numbers on the faces of the real die. To do this, it quickly turns each LED on in sequence when the start button is pressed, stopping with one LED on when the button is released. Because the circuit cycles through the sequence very quickly it is not possible to cheat by waiting for a particular LED to light and release the button at this point!

The circuit can be broken down into two sections, one dealing with the display and the other with timing and control signals. The latter are provided by two 'classic' circuit building blocks, namely the 'astable' formed by IC1a and IC1b and the 'monostable' configuration of IC1c and IC1d.

Each circuit is formed from two out of the four logic gates of IC1. The inputs of the logic gate can be in one of two conditions. They can either be 'low' that is, near O V), or 'high' (near to the supply voltage, 9V in this case). The output of the gate can also adopt only these two values, the choice being determined by the state of the inputs. In this case as the gates are 'NAND' gates the output will be high at all times except when both the inputs are high at which point the output will go low. 'NAND' stands for 'not-and', the output being low whenever both one input 'and' the other are high.

The astable will not function until the start button takes one of IC1a's inputs high. At this point the output of IC1b will oscillate between 0V and 9V. The circuit is referred to as an astable meaning 'not stable') because the output can assume these two conditions but is stable in neither.

A detailed description of the circuit would take up too much room but briefly the oscillator works like this: Suppose the output of IC1a is low and that as one of this gates' inputs is 'tied' high the other, connected to R3, must also be high. The junction of R3, R4 and C5 is thus high, but as R4 goes to the output of IC1a, which is low, the charge on C5 will leak away. At some point the voltage at this junction, having fallen to near the 0V rail, will cause the output of IC1a to go high and that of IC1/b to go low. C5 will now charge up via R4 which will in turn cause the circuit to assume its original state.

The series of pulses generated by the astable is fed to IC2. This is a counter IC, having ten outputs. As the pulses are fed to its input, each of the ten outputs will be turned on in sequence. For this circuit, however, we only want the IC to count up to six. To achieve this we connect the seventh output of IC2 to another of the IC's inputs called the 'reset' pin. When this pin is taken high it resets the counter back to the start. We now have our count of six.

The outputs of IC2 are taken to LEDs 1-6. LEDs are like ordinary diodes in that they will only pass current in one direction, but in addition when they are passing current will emit light. When an output of IC2 is high the associated LED will emit light if the common point to which the LEDs are taken, R6, is low.

R6 is taken to the output of IC1d. This point is normally high and thus the LEDs are all off. When the start button is released, however, the input of IC1c, junction of C3 and R1, goes low for a brief period of time and causes the output of this gate to go high. C4 'couples' this change to the input of IC1d and causes the output this gate to go low, activating the display and, by virtue of the fact that the output is also connected to IC1c, maintaining the high on the output of this gate. The charge of C4 will leak away, however, via R5 – and cause the circuit to assume the previous state after several seconds. This circuit is termed a monostable because it has two possible states, only one of which is stable (mono = one). It is necessary to include R6 in the circuit because the current passed by the LEDs must be limited to a safe value.

C2 and C1 are included to 'decouple' the supply that is, remove any fluctuations in the supply voltage that might upset circuit action.

Choosing a Calculator

A few years ago the pocket calculator would have been considered a miracle. Then it became a novelty and now it has become an everyday object. This rapid growth has brought with it a vast range of different calculator types and variants. Phil Cohen explains some of the more common jargon to help the prospective buyer choose.

FOUR-FUNCTION

[+] [−]

[÷] [×]

WHAT IS IT?

This means that the calculator can add, subtract, multiply and divide.

WHO NEEDS IT?

These facilities are common to almost all calculators — even the cheapest. For the majority of calculator applications these will be sufficient for adding columns of figures, calculating VAT and checking wage slips. On the other hand, while more advanced calculator functions are not essential, they are sometimes useful and always fun to play with!

8-DIGIT ACCURACY

12345678

WHAT IS IT?

This refers to the fact that the calculator can work with numbers up to 8 digits long (such as 1.2345678 or 12 345 678).

WHO NEEDS IT?

Calculator accuracy is, in general, much better than is required. Eight-digit calculators have become standard (although some run to 12 digits) and it is very seldom, if ever, that their full accuracy is required for any application.

OVERFLOW INDICATOR

Error.

WHAT IS IT?

'Overflow' occurs when the calculator is asked to perform a calculation which will give a result too large to display (such as 1 ÷ 0 = ?). The calculator will then display some appropriate message or symbol.

WHO NEEDS IT?

This is common to *all* calculators and advertisements sometimes mention it as a facility on cheap calculators which have few other facilities.

CONSTANT

[K]

WHAT IS IT?

Say, for instance, that you have a column of figures and want to find out what 8% of each of them is. If the calculator does not have a constant facility, you will have to enter each number and then ".08 =" after each one. Using the constant, all you have to do is to put in ".08 × K" at the start and then enter each number in turn and press the "=" key to find the answers. The calculator has remembered the ".08X" and saves you the trouble of re-entering it each time (See 'Programmable').

WHO NEEDS IT?

This allows a repetitive calculation to be performed easily.

Fortesque, Fortesque & Fortesque Esquire.

"Don't you have anything that will go with mink?"

FULLY-FLOATING

1. 23

WHAT IS IT?

A 'fully-floating' calculator can work in fractions. Calculators which are not fully-floating can only work in whole numbers. Calculators which can work in fractions have a decimal point key.

WHO NEEDS IT?

Very few calculators are not fully-floating and the ones which are not are usually the very cheapest. It is well worth the extra expense to be able to work in fractions of a pound rather than to have to work in pence.

PERCENTAGE KEY

%

WHAT IS IT?

The percentage key is a convenience function, used to reduce the number of keystrokes in calculations.

WHO NEEDS IT?

If you want to find out what 12.2% of 43 is, you could use ".122×43=" or "12.2÷100×43=" or, if your calculator has a percentage key "12.2%×43=". Each will give the same answer, but the third is easiest to understand.

SCIENTIFIC NOTATION

1. 23 04

WHAT IS IT?

When working with very large or very small numbers, an 8-digit calculator cannot display any number greater than 99 999 999 or smaller than 0.000 000 1. One way of getting round this is to move the decimal point around in the number and display the number and the number of places the point has been moved:

1234.5 = 3

1.2345 3

Notice that you can get the original number back again by multiplying the value shown by 10 a number of times. The number of times is the number shown to the right

$$1.2345\ 3 = 1.2345 \underbrace{\times 10 \times 10 \times 10}_{\text{3 times}}$$

$$= 1234.5$$

With very small numbers the number-of-times-to-multiply-by-10 (also called the *exponent)* is negative, this means *divide* by 10 three times.

$$1.23\ \text{-}3 = 1.23 \underbrace{\div 10 \div 10 \div 10}_{\text{3 times}}$$

$$= 0.00123$$

WHO NEEDS IT?

Most 'scientific' applications will require this facility (including school work after the age of about 16).

ALGEBRAIC LOGIC

(1+2)x3=

WHAT IS IT?

This refers to the organisation of the machine — a problem entered on an algebraic logic calculator is entered as it is written. The alternative to this type of organisation is 'Reverse Polish Notation' (see inset).

WHO NEEDS IT?

In general, algebraic logic is the easier to use but RPN has its advantages — it is faster (once learned), does away with the need for brackets and is used in the more advanced scientific calculators.

MEMORY

M

WHAT IS IT?

By using a calculator's memory, any number which has been worked out on the calculator can be stored for future use while the calculator is being used to work with other numbers. Many calculators have several memories which can be used independently.

WHO NEEDS IT?

The use of memory is equivalent to writing down the number for future use (although if the calculator is switched off it will suffer a sort of electronic amnesia and forget everything). In the example given in 'Parenthesis' the following key sequence could have been used (M='store in memory' key, MR='recall from memory' key) "2×5=M 3×4=+MR=". The number 10 would have been temporarily stored in memory.

SUMMING MEMORY

M+ M-

WHAT IS IT?

The M+ button adds whatever is being displayed to the memory. The M– button subtracts the display from the memory.

WHO NEEDS IT?

If you have two columns of figures

2	9
6	14
4	3

and you want to find out what (2×9) + (6×14) + (4×3) is, the easy way to do it on a calculator with memory would be "2×9 = M+6×14 = M+4×3 = M+ MR". This does away with the need for brackets in this example.

FOUR-FUNCTION MEMORY

M+ M- MR MC

WHAT IS IT?

This means usually that the memory can be added to, subtracted from, recalled or cancelled (set to zero). Some calculators also have Mx, which allows (2+9) × (6+14) × (4+13) to be worked out in a similar way to the example above.

WHO NEEDS IT?

Memories in a calculator are useful only occasionally and even then require more effort than at first seems to be the case. The use of Reverse Polish Notation renders memories to a certain extent unnecessary.

PARENTHESIS

( )

WHAT IS IT?

Brackets. Parenthesis keys on a calculator are used in the same way that they are used when a problem is written down (2 × 5) + (3 × 4) = ? tells the calculator to work out 2×5 and *then* add 3×4.

WHO NEEDS IT?

This is useful, but not essential. The alternative is to do the following "2×5=" answer 10 — write it down. "3×4=" answer 12 "+10=" answer 22

Parenthesis is useful for evaluating formulae, but RPN is better (see inset on Reverse Polish Notation).

PROGRAMMABLE

lrn run

WHAT IS IT?

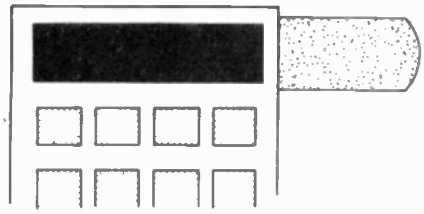
This facility allows the storage of a sequence of keys which can be 'played back' any number of times on request.

WHO NEEDS IT?

If you have a column of temperature results from an experiment, say, and it is required to convert them from C to F, the key sequence for the conversion (÷ 5 x 9 + 32) can be put into the calculator and called up for each value in turn. This feature is very useful for engineering and science students.

Choosing a Calculator

CARD-PROGRAMMABLE



WHAT IS IT?

This type allows you to store the keys which you programmed it with on a card about the size of a stick of chewing gum. The card is coated with a magmetic material similar to recording tape. A small motor in the machine draws the card through the calculator.

WHO NEEDS IT?

This type of machine is so expensive that it is really only cost-effective for engineering consultants and astronauts. However, if you *can* afford one (at a couple of hundred pounds), they're probably great fun to play with.

FULLY SCIENTIFIC

WHAT IS IT?

This means that the calculator can work out square roots, logs, sines, cosines and other 'scientific' functions.

WHO NEEDS IT?

These functions are in use from the age of about 13 upwards in the educational system and in any case are fun to play with.

FUNCTION KEY

WHAT IS IT?

This enables each key to be used for more than one thing. It works like this there are two sets of markings on each key (usually one on the key and one above it). There is also a key set aside from the rest, usually marked with an F. After this key has been pressed, the next key will have the effect which is written above it.

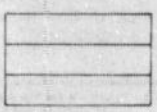
WHO NEEDS IT?

A function key allows more functions to be built into a machine of a given size. Unfortunately, it also makes it more difficult to use. Some machines have *two* function keys — each of the rest of the keys have three sets of markings on them in different colours. This makes the calculator almost impossible to use quickly.

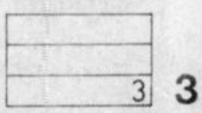
REVERSE POLISH NOTATION (RPN)

There is a rumour that Reverse Polish Notation (or RPN) was so called because the most difficult European language to learn is Polish (or so the story goes) and people considered RPN to be about as easy to learn as Polish backwards. This in fact not the case. RPN is named after its inventor. RPN is also easy to use (once you get the hang of it) and very quick to work with.

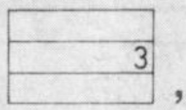
What is RPN? In order to explain, let's look at a simple problem 3×2+1=?. Most calculators will give you the answer if you key in the problem as it is written. On an RPN calculator the problem would have to be entered as 3, 2×1+ (the comma represents the 'enter' key). This is not terribly easy to follow at first. An RPN calculator has what is usually referred to as a 'stack'. This is a pile of memories, one 'on top of' the other



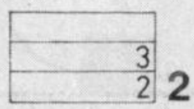
When the number 3 is entered in the example above, it goes into the lowest level of the stack. This is the memory which is shown on the display and so the display will show a '3'



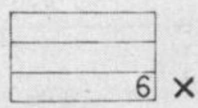
The 'enter' key (or comma as it is shown in the example) moves all the memories up one



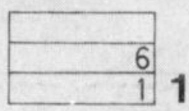
The 2 now goes into the bottom memory



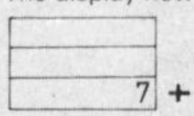
and the × multiplies the bottom two and puts the result in the bottom memory



The 1 goes into the bottom memory and pushes the results back up



and the + adds the two bottom memories and puts the result in the bottom. The display now reads 7.



RPN is not easy to learn — the easiest way to do it is to get hold of an RPN calculator and play with it. Once it has been learned, however, it does away with the need for brackets and makes calculations much easier.

LED DISPLAY

WHAT IS IT?

This is the type of display which is common on the cheapest and the most expensive calculators — not on the medium-priced ones! The display is made up of dozens of tiny light-emitting diodes (LEDs) which glow red when energised.

WHO NEEDS IT?

The disadvantage of LED displays is that they consume a lot of current — that is, they wear out batteries quickly. The advantage is that they change very quickly, giving an instant indication of whether a key has been pressed.

LCD DISPLAY

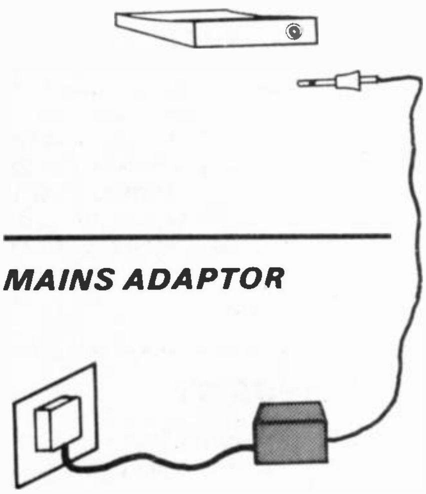
WHAT IS IT?

This type of display changes colour, parts of it going from clear to opaque to form numbers.

WHO NEEDS IT?

LCD stands for liquid crystal display. This consists of a fluid between transparent conductive plates. When a voltage is supplied to the plates the fluid becomes opaque. As this process is essentially chemical, it is very much slower than the LED type of display and this, especially if coupled with an absence of key-click (see above), makes if difficult to tell whether a key has been pressed hard enough. LCD displays take about 1/10 s to change (typically). The major advantage of LCDs is that they use very little power, extending battery life.

RECHARGEABLE



WHAT IS IT?

Rather than having to change batteries every so often, it is very useful to be able to recharge the existing ones. Unfortunately, this requires special batteries.

WHO NEEDS IT?

There are two disadvantages to rechargeable batteries. One is that they are expensive (in the short term). The other is that the amount of charge they hold is limited to a few hours continuous usage (for LED calculators), which is less than it seems. This means that the calculator has to be recharged (which usually takes about 12 hours) every couple of weeks, depending on how often the machine is used. Normal batteries will last several times as long and buying a new set is a lot less trouble than recharging.

MAINS ADAPTOR

WHAT IS IT?

This is a device which provides power in a form suitable for:

a) recharging a calculator's batteries or

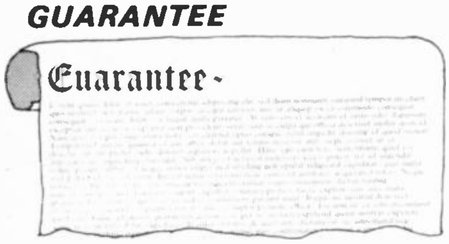
b) running the calculator without its batteries or

c) both a and b at the same time.

WHO NEEDS IT?

When buying a rechargeable calculator, be careful that you take into account the price of the mains adaptor — the calculator is virtually useless without it. Most dealers include the price of the adaptor in the price of the machine.

GUARANTEE



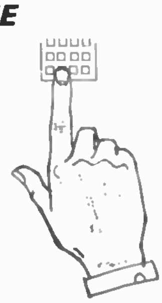
WHAT IS IT?

Calculator guarantees are of the standard sort usually found with small electronic equipment — ranging from 90 days to 1 year.

WHO NEEDS IT?

Calculators (especially the medium to expensive ones) are extremely reliable. As long as the machine works when it is bought and is not maltreated subsequently, it should last until the keys wear out — which is not covered by the guarantee in any case.

KEY SIZE



WHAT IS IT?

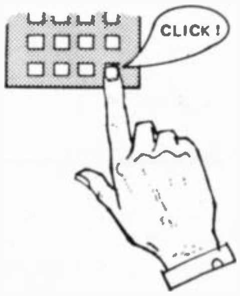
The major advantage of large calculators is that the keys are easier to hit. The disadvantage is loss of portability.

WHO NEEDS IT?

People with large fingers shouldn't buy calaculators with small keys. Don't be blinded by the compactness of a small machine — it is more difficult to use.

Choosing a Calculator

KEY-CLICK



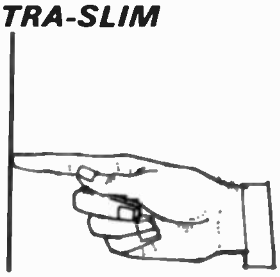
WHAT IS IT?

This is exactly what it says. When you press a key in, it goes "click". On some calculators the keys are silent, but a small loudspeaker in the device goes "beep" every time a key is pressed.

WHO NEEDS IT?

This is essential if the calculator is going to be used as anything except a toy. It is surprisingly difficult to tell whether a key has been pressed hard enough if this facility is not present. On the other hand, some manufacturers go too far and make keys which have to be pressed down very hard. The optimum depends on the individual.

ULTRA-SLIM



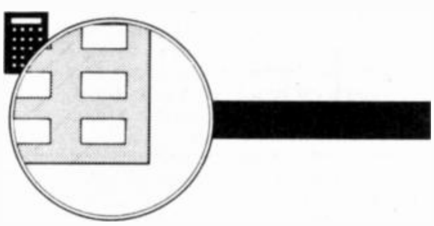
WHAT IS IT?

LCD technology (see above) has made it possible to produce calculators which run off hearing-aid batteries. This means that they can be made very thin indeed (less than ¼" thick).

WHO NEEDS IT?

The major advantage of ultra slim calculators seems to be that they will not produce an 'unsightly bulge' in the breast pocket. The disadvantage is that the key depression distance is limited, making the keyboard more difficult to use.

ULTRA-SMALL



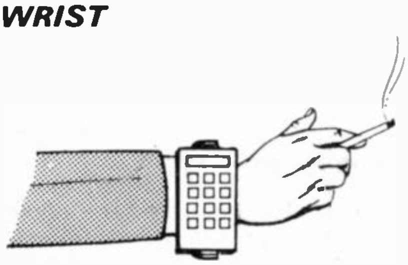
WHAT IS IT?

The same advances which make ultra-slim calculators possible also make it feasible to produce calculators which are so small that a pencil has to be used to press the keys!

WHO NEEDS IT?

This is all very well if you have pencil-shaped fingers, but not so good if you don't. To be fair, this sort of device is not much use for the 'serious' user (i.e. someone who wants to use the machine for arithmetic) but makes a good birthday present.

WRIST



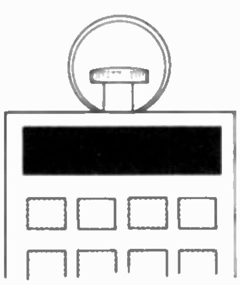
WHAT IS IT?

For those who feel they may be smitten by the urge to calculate at a moment's notice, there are some calculators available which come complete with a watch-strap and are of a size comparable to a watch.

WHO NEEDS IT?

Personally, I think this sort of thing is very silly indeed, although I suppose there must be *someone* who finds them invaluable.

STOPWATCH



WHAT IS IT?

One notable exception in the novelty calculator market is the calculator-plus-alarm-clock-plus-stopwatch. These are usually small enough to be carried in a pocket and consist of a display (LCD) capable of showing either the results of a calculation or the time of day, date, et cetera.

WHO NEEDS IT?

These machines are very useful — especially for reminding the user about parking meters, appointments, and so on (they're not loud enough to wake the user — well, not loud enough to wake me, anyway). In this combination of calculator-plus-clock the calculator is the tail which wags the dog — these devices are advertised as calculators although a miniature clock would probably be just as useful. The advantage of having the calculator in the same device is that it saves you carrying two devices.

electronics today international

What to look for in the January issue: On sale Dec 1st

CLICK! ELIMINATOR

Fed up with low quality records? Had a hard day and dropped your favourite LP? Kiddies used Bach for target practice?

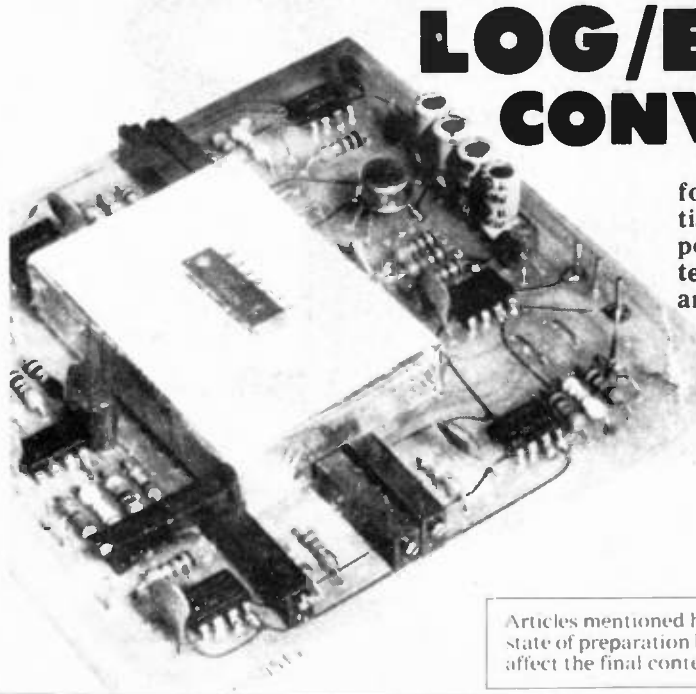
We can help — do not despair.

Next month we present a design to remove the clicks and scratches from records. The system works in a novel manner, and the system can be built at a fraction of the cost of commercial units.

DIGITAL TACHO

Compact, easy to build, 10 rev resolution, fast response due to PLL technique and a range to 9999 rpm. With all that going for it how can you afford to miss it? Suitable for standard, CDI, and transistor assisted ignition systems.

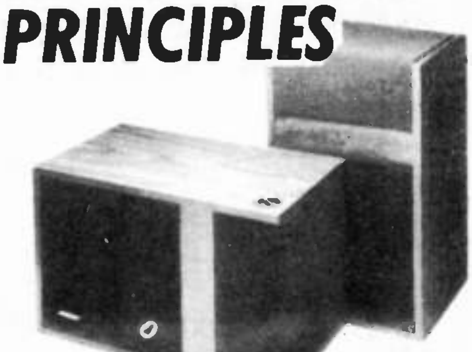
LOG/EXP CONVERTER



This design can be set up for either log or exponential convertion, and incorporates a neat heater for temperature stability. Has an eight octave range.

Articles mentioned here are in an advanced state of preparation but circumstances may affect the final contents.

LOUDSPEAKERS PRINCIPLES



An article to explain what goes on behind the grilles on those large wooden boxes dominating the living room. All the major types will be covered, moving coil electrostatic piezo-electric etc, as well as explanations of the different methods of 'loading' the units to do their job better.

computing today no 3

NEWBEAR'S BEARGAGS **are an economical way of adding extra power to any small system. Next month we take a look at a typical bag — the petitevid VDU II kit.**

BASIC II

Tandy's level two BASIC upgrade for TRS-80 machines is now available in this country — what extra power does this conversion provide?

COMPUTERS IN BUSINESS. A look at how one small businessman uses a microcomputer at work.

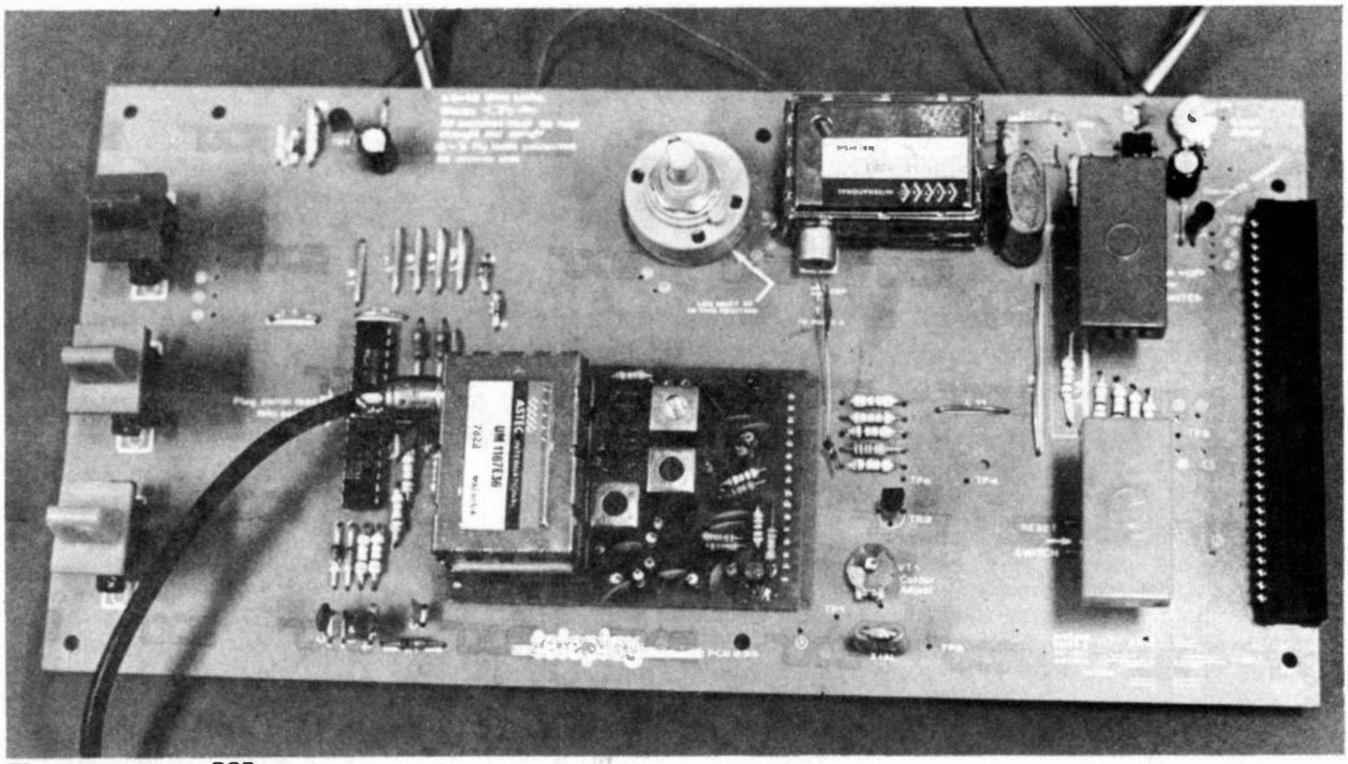
Kit Review —PROGRAMAGAME

With some TV games costing about a tenner, why should anyone buy a kit costing three times as much? However when the kit gives ten times as much enjoyment it should be taken seriously. We got our hands on this unit from Teleplay and put it through its paces . . . . .

WHEN TELEVISION GAMES were first introduced to the mass market they were all very simple — to play rather than make. The early versions used hundreds of separate logic devices, to produce two bats and bouncing ball — all the sound effects and scoring were performed by the players! These early units were produced by an American company by the name of Magnavox. It was up to another company, General Instruments, to produce a 'dedicated' circuit that was capable of generating display, score and sound effects. This pioneering device was the AY-3-8500, which had a repertoire of six games. Two of these games needed an external 'rifle', with built in light sensor and trigger, needless to say most game sets using the 8500 came without the 'rifle' — limiting the games to tennis, football, squash and solo squash.

Since the early days of the now obsolete AY-3-8500, General Instruments have developed several new games. Now you can emulate James Hunt, Evil Knevil or Rommel on your TV set, and the basic games now include basketball and target games that do not need a special 'rifle'.

The assembled programagame with game cartridge in place and hand controls connected



The programagame PCB.

HOW IT CAME

The kit was packed in several plastic bags, inside an expanded polystyrene container. The resistors, capacitors, transistors, etc were all in the same package. After sifting through all the parts and packs, to check them against the parts list, it became apparent that a rogue joystick pack had been included — and no mains adaptor at all!

There are different types of hand controller for different cartridges, the pack that had been included was meant for the stunt rider cartridge. A phone call to Teleplay produced apologies, the correct joystick pack and a mains adaptor by the next post. While waiting for them to arrive the main unit and cartridge were assembled.

ASSEMBLY

Construction is simplified by only having a single printed circuit board (PCB) and virtually everything fits directly on to it. First step was to fit all the wire links, resistors, diodes and capacitors — followed by the integrated circuits, crystals and transistors. As all the component reference numbers are clearly silk screened, on the board, the assembly was very straightforward.

The colour modulation circuitry is supplied pre-assembled on a small PCB, which fits on top of the main board, and is fitted like a large integrated circuit. All six switches were mounted on the PCB and the 32 way edge connector (for the plug-in cartridge) soldered in place at this point. After the switches were installed the board was mounted in the upper half of the console box. Both the DIN connectors (for the hand controllers) were supplied with leads fitted and the loose ends were remaining part of the console were the loudspeaker and power socket, which is a 3.5mm mini jack. From start to finish, the console took about two hours to construct.

Compared to the console, the cartridge was a doddle, with less than a dozen parts on the PCB — it took only ten minutes to assemble. With the console and cartridge assembled it only needed power, the hand controllers, and a colour TV to try the system out. Each hand controller took a further ten minutes to assemble, then came the moment of truth!

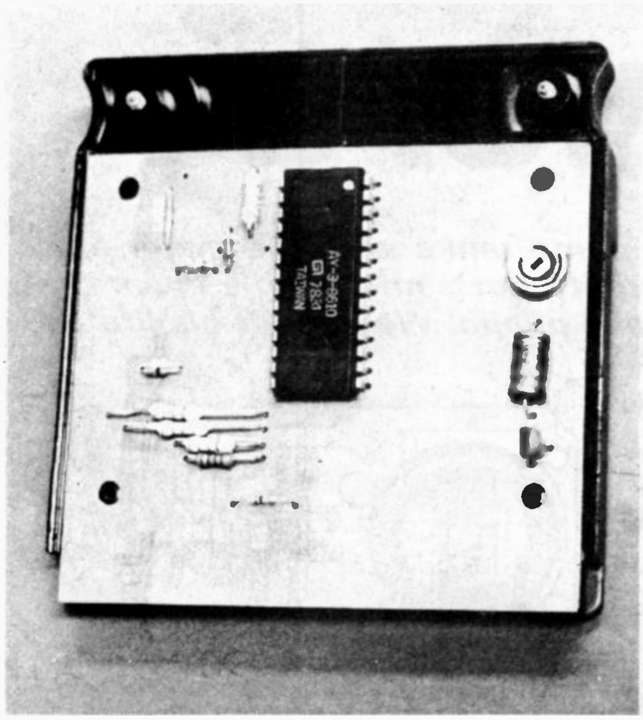
TRYING IT OUT

After a final check to see if everything looked correct a TV was connected to the Programagame and the system switched on. Hey presto! Nothing, apart from a plip plop out of the loudspeaker. Of course, I'd forgotten to tune in the TV to the channel that the game was transmitting on. A quick turn of the dial soon found a game of basketball in full colour, but the bats wouldn't move.

A bit of detective work soon uncovered the culprit — me. I'd missed out a couple of the pins on the 32 way edge connector when soldering it, when soldered the bats worked. All the games worked as expected. and the three handicap switches also functioned correctly — changing bat size, ball size and speed.

Overall the Teleplay Programagame kit is well thought out, the 12 pages of instructions contain enough information for most people to build it. With the availability of different game cartridges it is an economical way of having fun with your TV, and not getting completely bored with the same game selection, over and over again.

SLOT IT IN



Inside the game cartridge.

The main drawback for the home constructor to all the games has been cost. Each time a new game is released the design of a complete system is published, but you have to purchase a case, power supply and hand controllers. As well as the hardware duplication, you also end up building identical blocks of electronics, to produce oscillators, colour encoders and VHF modulators for each separate game.

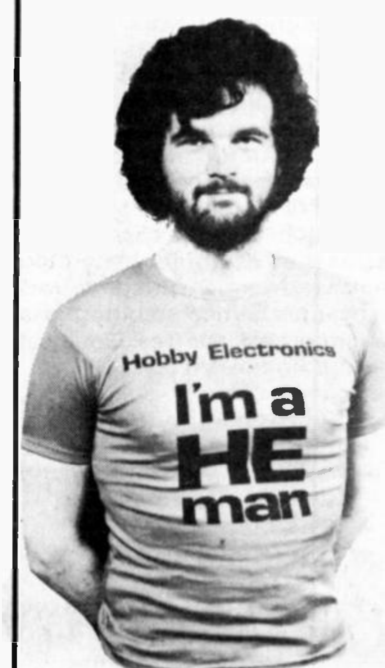
The Teleplay Programagame is designed as a main console, with all the common electronics inside — the actual game circuit is fitted inside a plastic cartridge, which slots into the console. In this way it becomes a simple matter to update the unit, as new games become available, you just plug in a new cartridge.

With the basic kit you receive a ten game cartridge that enables you to play football, basketball, tennis, gridball, hockey, target, squash and solo basketball, squash, target. All the games use the joystick hand controllers, which give bat movement across as well as up and down.

All in all, the kit, at about £30 is enjoyable to build, well thought out and, with the variety of games, is far more enjoyable to play than most of the offerings in this field. **HE**

The programagame kit in this article was supplied by Teleplay (at 14 Station Road, New Barnet, Herts EN5 1QW).

TEE-HE!



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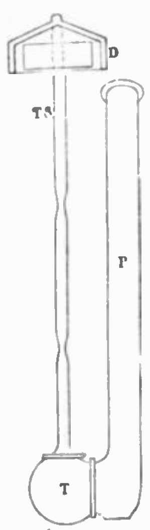
The Tesla Controversy

It is not doubted today that Tesla's name ranks with the major early researchers into the nature of electricity but some people claim that much of his work has never been made public. We look at his life and career . . .

BY THE BEGINNING of the 1880s, electrical machines were finding their way into both the commercial and domestic fields. Although the nature of AC was understood, practically all motors and generators were DC. Electricity was becoming accepted and arc-lamps, electric lifts, photo-flood lamps and a wide variety of other devices werea appearing.

In 1882 however, a young man Nikola Tesla who had been born in Smijan in what is now Yugoslavia, started to devote his undoubted talents to investigating AC. Tesla had the unusual flair for mental visualisation of highly complex ideas, a virtue shared by Faraday who was also working at that time.

At the end of 1883, Tesla exhibited a working model



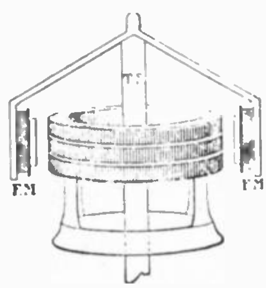


Fig. 2. Sketch of turbine and dynamo installed at Niagara Falls — 5000 horsepower at 2000 V. Ten units were installed. They consumed 26,000 lbs of water per second. Turbine (TS) shaft was 140 feet long of 38 in diameter. Penstock (P) delivers water to the turbine (T).

of an AC machine in Paris. (Figure 1 is one of Tesla's own pictures.) He then began a campaign hopefully to persuade the emerging electrical giants, such as the Continental Edison Company, that AC transmission was more efficient than DC and this resulted in a job offer to work with Edison in America. A chance soon came, the repair of DC generators in the ocean-going steamer "Oregon," for him to show his skills.

His work must have been good as he soon became Edison's chief assistant.

A few years later Tesla set up his own laboratory from which he finally reported (in 1888) the electromagnetic rotary field which enabled three-phase power transmission to be implemented. Shortly after this, George Westinghouse, of Westinghouse Electric Co., bought into Tesla's interests and built a hydro-electric system

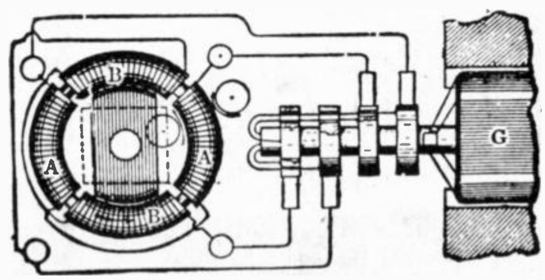


Fig. 1. Diagram used by Tesla in "The Electrician" to explain how a rotating field may be produced by a poly-phase system.

(see Fig. 2) of enormous proportion at Niagara Falls.

Tesla was a man of great generosity. It is said he tore up a contract binding Westinghouse to pay him $12 million — saying that it was more important for the Niagara plant to keep the home-lights burning than for Westinghouse to become bankrupt because of a debt to him.

TESLA AND RADIO

Notwithstanding his already significant work in power electrical engineering Tesla turned to thoughts of higher frequency (RF) currents — higher by far than the typical 100 Hz limit of power generators of that time.

The pioneers of radio had shown how a spark discharge, produced with an inductor and capacitor (Leyden jars to begin with) was finally proven to be an oscillatory process lying typically in the radio frequency band. Rigs that produced such discharges continued to be developed. The addition of a vibrating bell-like contact or spark-gap discharge arrangements produced a continuous train of discharges. When step-up transformer action was also incorporated, the Tesla coil was formed. (Another name is the Ruhmkorff coil.) Figure 3 is a 1910 Tesla apparatus.

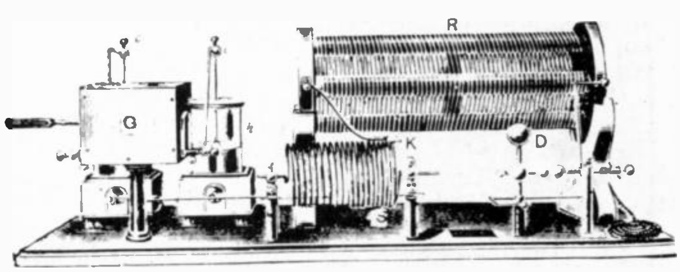


Fig. 3. Modern (at least in 1910) Tesla coil apparatus.

It was the spectacular things Tesla did with his radio frequency extremely high voltage generators that gained him so much fame. At a lecture to the American Institution of Electrical Engineers, given around 1891, he made a memorable impression being reported at the time as

> *"his work places Tesla among the greatest of our present-day scientists and inventors, such as Edison, Graham Bell and Thomson."*

MADE HIS MARK WITH SPARKS

Invitations poured in for his spectacular displays with man-made lightning and RF discharges. His equipment used two kinds of generator.

The first was a 384 pole AC dynamo running at 50 revolutions per minute to give 19.2 kHz. The other was a Ruhmkorff-type induction coil used with a condenser (capacitor) and a spark gap. This produced the then amazing half a million volts at "scores of thousands of cycles per second". It was the latter that impressed his audiences, for Tesla *"brandished flaming swords like an archangel"* — see Fig. 4 (or should it be arc-angel! — Ed).

Fortunately for everybody these RF discharges were

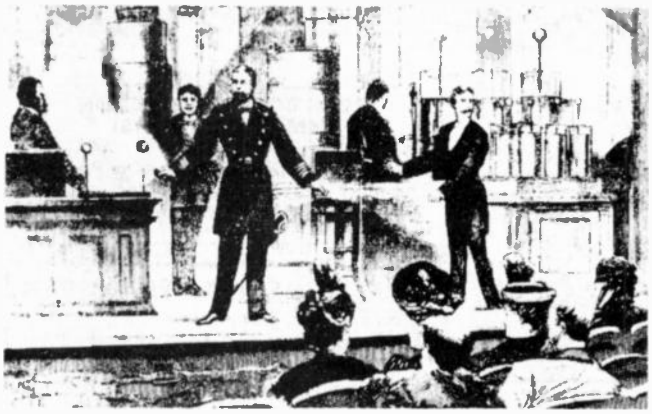


Fig. 5. A contemporary print of Tesla's experiments conducted in Berlin in 1894.

not lethal but Tesla said when about to try them out for the first time (experimenters were naive to say the least), *"it was as if I were poised to jump from Brooklyn Bridge"*.

Demonstrations included drawing arcs between a string of people, as recorded, Fig. 5, in a contemporary magazine. Another was to make Geissler tubes (glass tubes filled with rarified air but having no electrical contact with external circuits) glow whilst suspended between, but well free of, the poles of high high-voltage transformer.

In his 1899 he built a huge experimental barn at Colorado Springs in Colorado — 30 metres long and 7½ metres wide on top of which was a 25 metre tower supporting a 60 metre mast. At the top was a 1 metre diameter copper ball.

He subsequently proved the earth is electrically charged at a high potential. The Los Angeles Free Press reported visionary ideas not yet exploited — use of the earth's resonance energy and the launching of waves of electrical energy to transmit power to places remote from generators. There was talk of charging the earth to produce tremendous voltages and of terminals to extract it. Tesla is said to have *'lit 200 incandescent lamps at a*

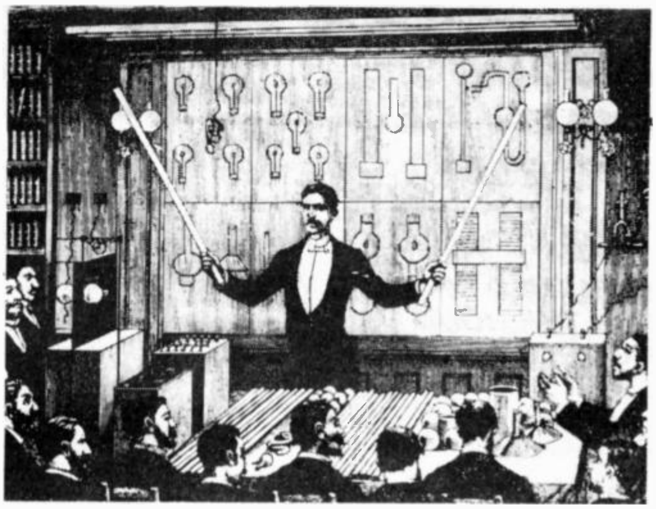


Fig. 4. Tesla amazed the scientific world in 1893 by holding glowing tubes aloft without any electrical connections being made to the tubes.

distance of 26 miles'. It is said his ideas failed to be exploited by commerce because the transmitted electricity could not be charged for.

POWERFUL SECRET?

Tesla died in 1943, his last work being on the use of cosmic rays as energy sources. The Free Press report claimed that the FBI seized his papers and confiscated all of his reports.

Did Tesla have a unique and powerful secret? He certainly was a visionary, perhaps he did discover something great that is being withheld.

It has been suggested that the Russians have recently found out how his way-out experiments were done and in doing so have tapped some new form of energy. Frankly we doubt if there is any truth in the suppression — or rediscovery — of his work but a lot of people do not agree.

Today he is truly acknowledged. His name is used as the now adopted unit of magnetic field insensity and most laboratories possess Tesla-coils for ionising gas in evacuated tubes.

HE

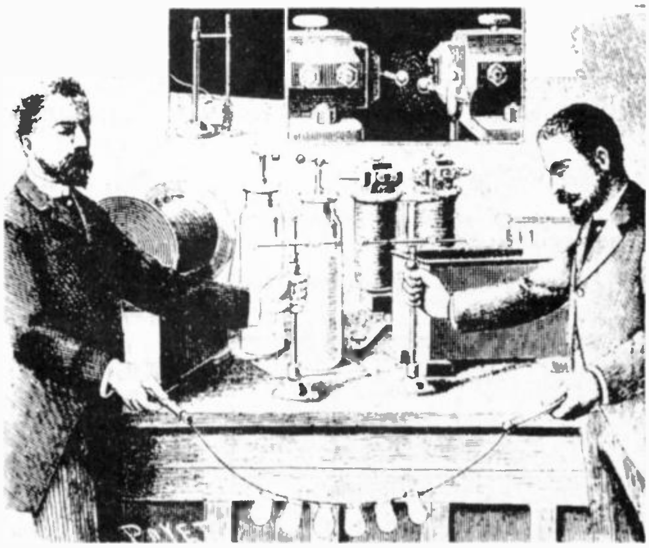


Fig. 6. This print of 1894 shows the laboratory equipment used in Tesla's experiments.

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Good Evans

Gary Evans shows us another peek at the latest developments

WHICH CAME FIRST — The customer or the chip? I ask because I remember the days when it was fairly obvious what any new IC from a semiconductor manufacturer was meant to do. Market research had been carried out, a "need" identified and the device to suit designed and manufactured, with its release accompanied by comprehensive application information. A clear example of this sort of process are the early days of Transistor Transistor Logic (TTL).

The first series of TTL was designated Small Scale Integration (SSI), this referring to the number of logic gates on one chip. As manufacturers got better at producing the ICs so the number of gates it was possible to put in a single chip rose — what to do with the extra power? Field surveys showed that the simple logic functions of SSI were being combined in certain ways (to form shift registers, JK flip flops etc.) by many end users — it was obvious what to provide within MSI packages. ages.

The manufacturers, being very clever, kept on packing more and more into less and less until we reach the situation today when it is possible to implement the equivalent of a whole army of TTL circuitry onto a single chip of silicon. This is the situation that prompted my initial question.

With so much "Power" available and so much money invested in the development of any particular device, it is impossible for the semiconductor manufacturer to dedicate an IC to one specific function (unless he can predict vast sales of this one product i.e. the AY-8500 TV games chip). Instead he must try and go for an all-singing, all-dancing device that will try to appeal to as many users as possible. The danger is, of course, that it will appeal to nobody.

An example of this latest breed of devices that I had to deal with the other day is the ICM 7217/7227 series from Intersil.

If I say that the ICs are four digit, presettable up/down counters with an onboard presettable register continuously compared to the counter, intended for use in hardwired or process control situations, capable of driving common anode or common cathode displays, and providing either a decade count (9999) or timing count (5959)—you'll have some idea of an all-singing, all-dancing product.

People are undoubtedly going to use these ICs but one feels the device has no particular user in mind — It's rather a blitz approach.

RISE AND CHIME

One of the most difficult things I find about doing my job is getting up in the morning. Enjoying my daily toil as I do, it's still an enormous task to convince my sleeping body that the time has once again come to report for work.

A few years ago I was woken up by the most effective of alarm clocks, organic based, it never failed to wake me and made the whole process of returning to the land of labour all the more pleasant by providing various foods to set me up for the day. The device was, needless to say unique and usually referred to as Mum.

My first digital clock met most of my requirements. It never stopped, didn't keep me awake by ticking and had an alarm that bleated for an hour — more than enough to overcome any early morning reluctance on my behalf.

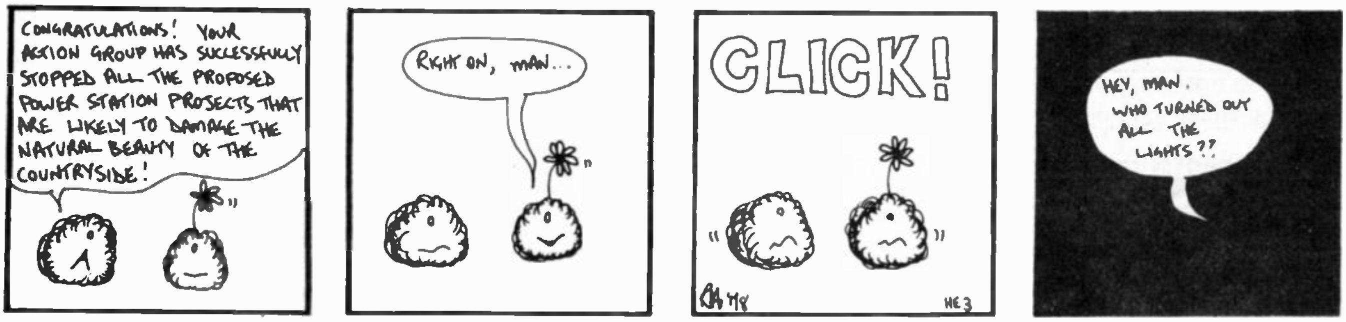
Going back to my fondly-remembered organic system, though, I still missed some sustenance at waking up time. The solution was to build my own tailor made system based on the "STAC" timer from National.

This is a programmable timer that has four outputs each of which can be connected to various items of apparatus and can be switched on or off at four selectable times.

Connect one output to a kettle, one to the bedside lamp, another to the radio and the last to a loud buzzer and you have the perfect alarm system that can be adjusted to your own needs.

Radio first, followed by light and kettle with alarm timed to coincide with the boiling of the kettle, or perhaps kettle first with the rest going off in one go as the kettle boils — it's up to you.

It works for me — not only do I get to work on time but I'm able to get on with it when I arrive having been fortified with the vital early morning cuppa.

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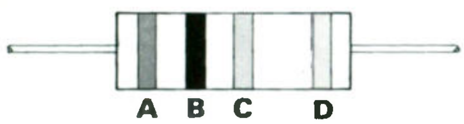
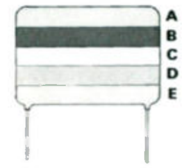
RESISTOR COLOUR CODE



	A and B	C
BLACK	0	- - ohms
BROWN	1	- - 0 ohms
RED	2	- k -
ORANGE	3	- - k
YELLOW	4	- - 0 k
GREEN	5	- M -
BLUE	6	- - M
VIOLET	7	
GREY	8	
WHITE	9	

	D (tolerance)
NONE	20%
SILVER	10%
GOLD	5%
RED	2%
BROWN	1%

CAPACITOR COLOUR CODE



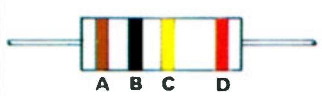
	C
BLACK	- - p
BROWN	- - 0 p
RED	- n -
ORANGE	- - n
YELLOW	- - 0 n
GREEN	- u -

	D (tolerance)
BLACK	20%
WHITE	10%
GREEN	5%

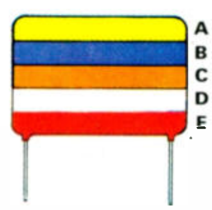
	E (voltage)
RED	250 V

A and B: As for resistors.

EXAMPLES:



A = 1, B = 0, C = - - 0 k, so value is 100 k; D = accuracy = 2%



A = 4, B = 7, C = - - - n, so value is 47 n; D = accuracy = 10%; E = voltage = 250 V

BRITISH STANDARD COMPONENT MARKINGS

M (pronounced mega) means multiply by 1 000 000,
k (pronounced kilo) means multiply by 1 000,
m (pronounced milli) means divide by 1 000,
u (pronounced micro) means divide by 1 000 000,
n (pronounced nano) means divide by 1 000 000 000 and
p (pronounced pico) means divide by 1 000 000 000 000.

So when we write 10 mV, we mean (10 / 1000) V, or 0.01 V. Note: it is usual to leave the "F" and "ohm" out altogether when writing, but as we rarely talk about resistances less than one ohm or capacitances greater than one farad, this does not cause *too* much confusion.

Examples: 10 uV = (10 / 1 000 000) V = 0.000 001 V; 330 R = 330 ohms (R is used for ohms when no multiplier is needed); 10 k = 10 000 ohms; 3.9 mV = 0.003 9 volts; 3.9 u = 0.000 003 9 farads.

Now, at some stage, someone decided to jazz up the system by putting the suffix in place of the decimal point, so that: 4k3 is 4 300 ohms and 4u9 is 0.000 004 9 farads.

Also, in case one of the digits got lost, it was decided that there should always be at least three numbers or letters in the value, so: 5k is written 5k0, et cetera.

Examples: 3M0 = 3 M ohms = 3 000 000 ohms; 4n5 = 4.5 nF = 0.000 000 004 5 farads.

INTEGRATED CIRCUIT NUMBERS

TTL: (SN)(7490) — SN = manufacturer; 7490 = device function (2 or 3 digits)

Example: DM 74121

CMOS: (CD)(40)(42)(A) — CD = manufacturer; 42 = device function (2 digits); A = electrical fragility (A = do not handle — static charges will destroy device; B or C = protected against static)

Example: CA 4015 B

OTHER TYPES: (uA)(741) — uA = manufacturer; 741 = device function (3 or more digits)

Examples: LM 309, CA 3011, NE 555

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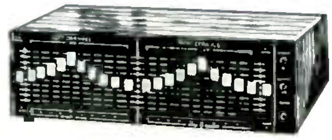

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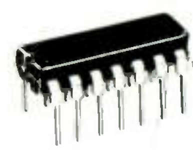

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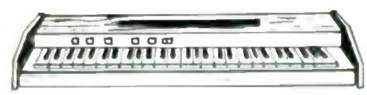

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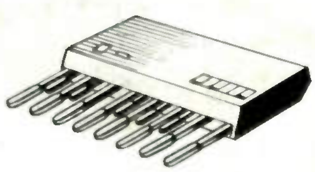

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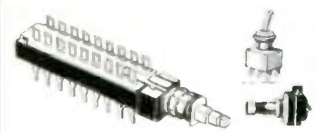

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